CHILDREN WITH RECURRENT OTITIS MEDIA AUDITORY ATTENTIONAL BEHAVIORS UNDER STRESS

BY

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This dissertation
is dedicated to
my son, Rick,
who was the best
I will ever achieve.

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TABLE OF CONTENTS

		Page
ACKNOWLEDGMENTS		iii
ABSTRACT		vii
CHAPTER		
I	BACKGROUND AND PURPOSE	1
	Introduction	1
	Review of Literature	8
	Statement of Purpose	51
II	METHODS	55
	Introduction	55
	Subjects	56
	Measurement	61
	Procedures	71
III	RESULTS	76
	Auditory Attentional Effects	76
	Performance Analysis	87
	Predictive Value	97
IV	DISCUSSION	106
	Interpretation of Results	106
	Conclusions	120
	Implications for Future Research	128
	Summary	139
APPENDIX		
A	PARENTAL QUESTIONNAIRE	141
B	CONSENT FOR PARTICIPATION IN RESEARCH	144
C	RAW DATA	146
D	ORAL TEST DIRECTIONS GIVEN TO SUBJECTS	148
E	TEST BATTERY PROTOCOLS	150

TABLE OF CONTENTS (Cont.)

APPENDIX Page

F RESEARCH TAPE RECORDINGS SUBTEST PRESENTATION ORDER 162

BIBLIOGRAPHY 163

BIOGRAPHICAL SKETCH 173

Abstract of Dissertation Presented to the Graduate
Council of the University of Florida in
Partial Fulfillment of the Requirements for the
Degree of Doctor of Philosophy

CHILDREN WITH RECURRENT OTITIS MEDIA.
AUDITORY ATTENTIONAL BEHAVIORS UNDER STRESS

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Children with a history of recurrent otitis media (OM) before age three years comprise a significant portion of many clinical caseloads. Such children exhibit speech and language disorders with concomitant auditory processing deficits often described by clinicians as auditory attentional problems. Studies have been published which report significant differences when OM subjects are compared to children defined as having normal communication abilities. Recent reviews of this literature have sharply criticized the methodology and theoretical base of much of this research activity. Nevertheless, the weight of evidence indicates that OM children frequently present communicative dysfunction when compared to a normal population.

This study was proposed to assess whether the auditory processing deficits demonstrated by OM children were uniquely descriptive of that population when compared to another group of communicatively handicapped children. Twelve children aged 4:3 to 7:5 years, with a history of recurrent otitis media before age three years (OM), were compared to a similar group of twelve children without such a history (NOM). Four tests of central auditory abilities were modified in order to provide conditions where auditory attentional behaviors could be stressed or facilitated. Rigorous methodological constraints were imposed during subject selection, test administration and data analysis procedures.

Both groups exhibited large deficiencies in their ability to respond on auditory attentional tasks, but no significant differences on individual subtests were found between groups. Discriminant analysis of test results did provide a prediction of group classification at a 75% accuracy level. Some differences in distribution of scores between stressed and facilitated attention test conditions were noted between groups.

It was suggested that the comparison of samples of OM children to other language disordered populations provides a meaningful technique for qualifying the symptomology of this clinically prevalent population. In addition, some of the methods and procedures employed in this study were recommended in answer to many of the criticisms levied against the existing otitis media research literature. It

was suggested that future research activity in this area pursue the establishment of a normative data base, refinement of methodology and longitudinal investigation of cognitive strategy development.

CHAPTER I
BACKGROUND AND PURPOSE

Introduction

Children exhibiting communication deficits in which auditory processing appears to be a factor comprise a major portion of the clinical caseload found in any program offering speech pathology and audiology services. Their communication disability is manifested in a variety of forms such as misarticulation of speech sounds, retarded development of grammatical or syntactical linguistic forms, deviant phonologic or semantic systems. In an attempt to define parameters of such a problem, and in search of its etiology, clinicians often identify behaviors which indicate that auditory information is being used inefficiently by these children. For some in this clinical population, audiometric testing reveals a loss of auditory acuity which results in attenuation or distortion of a portion of the acoustic environment. Medical and therapeutic treatment is often successful in remediation of much of the communication deficit, especially when discovery of such a factor occurs early in the child's speech and language development.

The literature resulting from studies of the congenitally and adventitiously deaf and hearing impaired populations

demonstrates that both phonatic and linguistic deficits result from loss of acoustic information. In these cases, it is difficult to separate dysfunction due to acoustic reception problems from those due to auditory perceptual problems. Such a separation might be possible through study of a population whose communicative dysfunction was characterized by mismanagement of auditory information although acoustic receptive skills appeared to be intact. If, furthermore, some evidence existed that some retrocochlear structures and central neurophysiological functions associated with auditory perceptual processes were anomalous in this population, then justification for exploring the perceptual operations attributed to these structures and functions would exist. The population of children with a history of early recurrent otitis media meets these specifications.

An example of such a child is given in a case study by Eisen (1962). Eisen attempts to further specify causality for the child, whom he describes as a seven year old boy with academic, communication and behavior problems, an unnoticed history of otitis media in his first three years of life, but no evidence of current hearing loss. He describes this child's behavior in terms of inattention, poor listening skills and delayed responses to verbal stimulation, particularly apparent in stressful situations such as the classroom, where failure was experienced. Eisen explains this boy's problems as due to intermittent loss of auditory acuity due

to otitis media during critical linguistic developmental periods. For support, he cites the work of Bruner (1961) and Hebb (1949) which demonstrated adverse effects on strategy development and learning resulting from early sensory deprivation and the animal studies by Wolf (1943) showing exacerbation of sensory deprivation effects under stress.

It may be that a significant number of children identified as having speech and language problems with no obvious source of acoustic failure, although auditory processing skills appear deficit, share many of the symptoms and history of the boy described by Eisen. Audiometric examination reveals hearing for speech to be within normal limits, but assessment of otic history often points to episodes of middle ear disease and concomitant conductive hearing loss. This intermittent impairment is often signaled by the presence of an air-bone gap in pure tone thresholds, or by abnormal contours on tympanograms. Tests of operationally defined auditory perceptual skills sometimes reveal problems which, while symptomologically descriptive, contribute little to an understanding of the cause of the communication disability. This type of limited information renders the prescription of effective clinical intervention strategies difficult. Such children are described as experiencing problems with auditory perception, defined as discrete skills such as discrimination, figure-ground, conceptualization, sequencing closure and attention span. They are characterized by their parents, teachers and clinicians as distractible or

hyperactive. While such informal descriptions and formal test procedures may define some obvious or common manifestations of dysfunctional auditory skills, little information is obtained which elucidates the relationship of this auditory dysfunction to the communication disability. Furthermore, no anatomical structure or physiological process is implicated as the source of the dysfunction. Because the peripheral hearing mechanism appears to be intact and free of disease, such problems are frequently described as central auditory dysfunction for which symptomatic therapy is devised.

Current research activity using this population includes documentation of the existence of communication and learning disabilities, compilation of incidence figures, description of medical and social profiles, and obtaining of graphic and anatomic evidence of neurophysiological deviations. Unfortunately the studies extant in the literature, while establishing the existence of learning problems in children with a history of recurrent otitis media, cannot be used to discern the nature of the relationship between recurrent otitis media and the observed communication problems. The inchoate state of the literature is due partially to the methodological vulnerability inherent in retrospective research design used in these studies, and also to the lack of uniformity in an approach to this problem. Rapin (1979), in providing an overview of literature related to this area, points out the inconsistency of research focus from one study to another depending upon the

professional expertise of the experimenters. The result of this inconsistency is lack of coherence among the findings of the various studies. Rueban and Hanson (1975) summarized the conclusions reached at a workshop on otitis media and child development sponsored by the Communicative Disorders Program of the National Institute of Neurological and Communicative Disorders and Stroke. They stated that the consensus reached was that, while recurrent otitis media had a probable and significant effect on children's development, particularly in the area of language acquisition, "significant defects in design in most of the relevant literature prevented clear conclusions" (p. 111).

Nebulous explanations of the theoretical basis of defined auditory perceptual skills, and conflicting empirical evidence, have led to criticism concerning identification of an auditory processing disorder as the cause of many speech, language and other learning dysfunctions. Rees (1973), for example, points out the limitations of evidence for an auditory perceptual factor in language/learning problems. She discusses the fallacy of examining speech perception skills using non-speech stimuli, basing her argument on data resulting from work such as that by Lieberman (1972) and Liberman, Cooper, Shankweiler and Studdert-Kennedy (1967) which indicates that speech stimuli are processed differently from other acoustic stimuli. In addition, she indicates that the temporal nature of the speech processing task is such that sequential perception of individual phonemes could not occur. That means, Rees

contends, that processing of the acoustic information present in ongoing speech must be a selective sampling governed by the linguistic constraints recognized by the listener. She proposes that linguistic, rather than phonetic, perception may be the primary factor in speech and language acquisition and dysfunction. Rees concludes,

> The search for a single auditory skill, or even a set of auditory abilities, that is essential to language learning or impaired in all or most language-disordered children seems futile. We must therefore question the diagnostic value of tests that purport to isolate these skills, as well as the therapeutic value of clinical procedures designed to improve them. (1973, p. 312-13)

Such arguments do not disprove the importance of auditory function in speech and language operations. They serve, rather, to demonstrate the friability of a model of perception composed of discrete unidirectional processes leading to development of expressive communication skills. Certainly it is obvious that a child's communicative response to verbal speech stimulation involves some fundamental transformation of sound into a pattern which can be maintained in an internal environment for a period of time sufficient for formulation of a response. Tallal, Stark and Curtiss (1976) suggest that language development would be delayed because of a deficit in the ability to carry out acoustic analysis of incoming speech information. Menyuk, reviewing

studies of speech sound discrimination capabilities in infants, gives an example of how such skills could influence communication skill development:

> . . . the infant may be most sensitive to certain acoustic, if not speech, parameters that will play a crucial role in his comprehension and production of speech. Clearly such an aspect as plus or minus voice not only plays a role in speech sound acquisition but also in grammar acquisition since this aspect is used, for example, to mark number and tense differentially. (1977, p. 623-24)

The necessity for discovery of veridical correlations between an established, measurable physiological disease condition such as otitis media and auditory processing problems is obvious. Differentiation of symptomology between this group and other language/learning deficient populations could serve heuristically in the search for etiologies. The purpose of this study was to compare behavioral responses to some specific auditory processing tasks related to particular perceptual operations in communicatively handicapped populations with (OM) and without (NOM) a history of recurrent otitis media. Evidence was sought which would indicate that speech and language difficulties could be characterized by disparate auditory perceptual abilities which existed between the groups. It was hoped that the variance in an individual's auditory attention performance could be used to predict defined group membership. If such evidence was discovered, the implications for the relationship between attentional deficits and the neurophysiological

deviations suggested to be concomitant to otic disease could be delineated and further studies proposed. As Luria (1973) suggested, the study of such observed defects and the qualification of the symptomology can result in an identification of underlying basic factors in perceptual cognitive processing.

Review of Literature

Auditory Perception and Communication Disorders

Observable and distinct differences have been identified in the speech and language abilities of both child and adult populations where a known impairment in the peripheral or central auditory systems can be substantiated. The literature in adult aphasia, where disruption in communicative ability occurs in the presence of cerebral insult, indicates a relationship between damage to cortical areas active during auditory stimulation and deterioration of both receptive and expressive lingulatic skills (Brookshire, 1973, Eisenson, 1973, Schuell, Jenkins and Jimenez-Pabon, 1964). In children where a congenital or early adventitious hearing impairment is identified by elevated auditory acuity thresholds, delayed and deviant linguistic performance has been consistently documented (Pollack, 1971, Menyuk, 1977). For these populations, an anatomical or physiological source

of impairment can be qualitatively, often quantitatively specified using highly refined diagnostic measures and complex instrumentation, with results being supported by post-mortem and split brain studies.

Menyuk (1977), citing numerous studies which give evidence of differences in the vocalization behaviors of babbling in infants with and without hearing loss, discussed the importance of this stage to further linguistic development. She states that infants with severe hearing impairments show a reduction in spontaneous vocalization during this period and suggests that they are "obviously losing acoustic information of vital importance" (p. 625). It is during the babbling period, Menyuk contends, that the infant with normal auditory acuity begins to construct phonological categorizations employed in subsequent language acquisition activity.

A correlation between speech and language development problems and auditory dysfunctions has been found in other populations where the source and nature of the disruption are less well defined. In these cases, auditory acuity appears to be normal and no conclusive evidence of central lesions is obtained. Most of the dysfunctional populations used have been globally defined in terms of central auditory dysfunction, developmental dysphasia, learning disability and the like, with an inventory of behaviors used to describe the perceptual deficit symptomatically.

Many of the studies exploring the performance of auditory perceptual operations have found evidence of the importance of the temporal acoustic cues of stimulus frequency and duration in the information processing demands associated with speech and language performance. When normal communicators have been compared with dysfunctional communicators with these stimulus dimensions employed as independent variables, significant differences in adequacy of response have been found.

Beasley and Freeman (1977) describe studies where the temporal parameters of speech have been altered for potential use in the clinical evaluations of auditory perceptual dysfunctions. For example, time-compressed speech material requiring a picture-pointing response has been presented to children described as exhibiting reading impairment, learning disabilities, articulation disorders and hearing losses. Differences between children with these deficits and normal children have been reported in the work cited by these authors, with normal subjects showing less variability in their performance with speech material presented under 0% and 50% time compression.

Pinheiro (1977) assessed another group of children diagnosed as minimally brain damaged/learning disabled to determine if evidence of auditory processing deficits could be found using a series of tests which were designed to identify central auditory dysfunction. Definition of these subjects' learning disabilities included pretesting

indicating normal intelligence, visual acuity, auditory pure tone and speech reception thresholds, word discrimination scores and age-appropriate digit sequencing ability. Results of administering the series of seven central auditory tests indicated a similar pattern of response for all the children in this study, although differences in severity were noted. Pinheiro postulated a left hemisphere dysfunction manifested in problems with sensory-motor integration when dealing with acoustic temporal order cues.

A number of studies have examined the performance of children exhibiting auditory learning difficulties in the absence of peripheral hearing loss, intellectual or psychological deficits, using the Test of Central Auditory Abilities (CAA) (Flowers, Costello and Small, 1970). Based on prior studies and observations of unusual auditory behaviors in children with language and reading problems, but no apparent sensory or intellectual impairment, test materials employing speech stimuli presented under difficult listening conditions--a distracting competing message and low-pass filtered speech--were developed and normed on several hundred kindergarten children. These children were subsequently monitored for reading achievement in later grades so that their kindergarten CAA scores could be used predictively. Costello (1977) cites research by independent investigators using the CAA with children having language/learning problems and displaying a varied symptomology where poor CAA scores were supported by other test results and behavioral observations.

Children's processing problems with auditory temporal cues were specifically focused on in a study by Tobey, Cullen, Kampp and Fleischer-Gallagher (1979). In this study, the performance of normal and learning disabled children on a forced-choice identification task were compared. Stop consonant-vowel syllables were dichotically presented with inter-stimulus intervals (ISI) of 30, 50 or 150 milliseconds. Results revealed poorer performance by the learning disabled children both generally and on correctness for both members of a stimulus set. In addition, although control subjects were able to improve their identification performance on the first member of a stimulus set as the ISI was increased, the learning disabled subjects were unable to do so. All subjects showed greater accuracy on the second stimulus in trials where only one correct response was obtained. The authors concluded,

> These data suggest learning disabled children with auditory processing disorders may have a reduced temporal efficiency in processing rapidly varying acoustic patterns associated with stop consonants that is observable when speech perceptual mechanisms are stressed through dichotic competition. (p. 197)

Perhaps the most extensive study of auditory processing deficits in a language/learning disabled population has been the work of Tallal and her associates with children identified as experiencing developmental dysphasia

(Tallal and Piercy, 1973a, 1973b, 1974, 1975, Tallal et al., 1976). In a review of these studies, Tallal (1978) discusses the temporal processing problems revealed by her research. For the discrimination of nonverbal auditory stimuli, the factors of ISI and stimulus duration were found to be critical in the performance of dysphasic children. As stimulus presentation rate was reduced by increasing either the ISI beyond 350 milliseconds or the duration of the complex tone stimulus, these children's performance improved. When performance of this same population in the discrimination of verbal stimuli was examined, temporal processing problems were again indicated. Dysphasic children evidenced difficulty in same/different judgments and repetition for stop consonant-vowel stimuli where only a brief, transitional cue for difference is available but not for vowel-vowel stimuli where a longer, steady-state cue occurs. When manipulation of these synthetic speech signals reversed the temporal characteristics of the two stimulus types, the performance of the dysphasic children on the same/different judgments was also reversed. Because these children were now able to discriminate correctly between consonant-vowel stimuli with extended transition durations, Tallal concluded that the manifested auditory processing difficulty is related to the temporal nature of the transitional cue and not to the factor of transitional occurrence per se. Comparison of the performance of dysphasic and normal children with rapid presentations of auditory nonverbal

stimuli indicated that the dysphasic children's inferior performance pattern was different and not merely a case of delayed development. Referring to studies currently underway with adult subjects, Tallal suggests that the left cerebral hemisphere dominance, indicated by the phenomena of categorical perception and right ear advantage (REA) found in speech perception studies, may be a function of the temporal resolution capacity of that hemisphere rather than linguistic analysis.

The primary significance of acoustic temporal cues in the auditory responses of normal-hearing infants is confirmed by studies such as those reported by Friedlander (1970) and Eisenberg (1976). Stimulus duration, ISI and number of trials are all important factors influencing the processing of auditory information. It would seem, intuitively, that these factors all require the basic responses of orienting and selectively attending to stimulation. If a dysfunction in these responses was found in children with temporal processing deficits, then an examination of the underlying neurological and structural mechanisms thought to interact in such responses might provide clinically relevant data which could be applied in prevention and intervention programs. However, while some peripheral discussion of attention and selective listening skills appears in the literature cited in this section, discussion of anatomical or physiological substrates of these temporal processing deficits is largely

speculative. This may be attributable to the variety of symptom combinations and etiologies possible in the populations considered in these studies, and to the difficulty in obtaining any conclusive evidence regarding anomalous neurophysiological status.

There is a body of literature concerning a population in which can be found much of the same symptomology as in those described above. This population is often identified as a subset of populations of children termed learning disabled, minimally brain damaged, etc. In these children, however, a particular pathological condition occurring in the peripheral hearing mechanism and associated with deviant brain stem histology can be identified.

Otitis Media and Communication Disorders

In many of the studies cited previously where auditory processing dysfunction is a defining characteristic of subjects, the current status of their auditory acuity is often ascertained and a general developmental history considered. However, few reports indicate a specific investigation of otic history

Indications of the potential importance of information regarding previously existing ear pathologies can be found in the documentation of the prevalence of children with early histories of otic disease who develop educational and communicative deficits, and in the results of studies with animals where temporary, peripheral auditory dysfunction

has been induced during early life periods felt to be critical to normal development. Results of such studies have shown not only differences in auditory behaviors in these animals, often lasting long after return to anatomically and environmentally normal status, but also post mortem histological anomalies in brain stem structures of known importance for transmission of auditory information to and from higher central structures. The otic histories of these animal subjects have been designed to parallel the histories of the children with early recurrent middle ear disease who constitute a prominent proportion of the clinical caseloads of speech pathologists and other remedial specialists.

Identification and incidence of otitis media. The condition of otitis media is characterized by infection of middle ear membrane and restriction or blockage of the eustachian tube, often accompanied by mastoiditis, retracted or perforated tympanic membrane and intermittent, conductive hearing loss (Northern and Downs, 1974, Eliachar, 1978). It is attributable to a number of bacterial and viral causes and is generally described as chronic, acute or secretory. Eliachar (1978) states that secretory otitis media, usually a disease stage intermediate to chronic and acute, is the primary cause of conductive hearing loss in children who also show evidence of a high incidence of delayed language and learning disability.

This disease is a condition common to early childhood whose incidence may be underestimated because of problems in otoscopic and audiometric identification. Eliachar (1978) reports that hearing impairment resulting from otitis media may remain undiscovered by traditional audiometric screening and even pure tone and speech discrimination threshold tests. He recommends tympanometric assessment as the most effective evaluative procedure available. Glorig and Garwin (1972) also point out the possibility of undetected conductive hearing loss due to otic infections in young children where otologic and audiometric screening procedures only are employed.

Nevertheless, Northern and Downs (1974) cite a study by Eagles, Wishik and Doerfler (1967) in which the incidence of unilateral or bilateral otologic abnormalities indicating the occurrence of ear disease was 15.2% of the Pittsburgh school population. That incidence figure increased to 30% in a 5-year follow-up study. Northern and Downs report other studies which yield evidence of increased prevalence of ear disease in disadvantaged populations. Howie, Bioussard and Sloyer (1975a) found that, of 488 patients experiencing otitis media, 240, or 49%, were less than one year of age at the time of the first infection. This early occurrence was significantly related to repeated bouts with the disease before six years of age--termed an "otitis-prone" condition. A summary of recent incidence studies (Howie et al. 1975b) yields figures for occurrence of otitis media in 76-85%

of all children by age six years, with at least six bouts of the disease for 20-26% of the children in two studies.

Twenty-two children identified as hyperactive and learning disabled were compared with a sample of 772 normal children by Hersher (1978). A higher incidence of the otitis-prone condition was found in the hyperactive group (54% vs. 15%). Freeman and Parkins (1979) also report an increased incidence of otitis media in a sample of 50 learning disabled children compared to 32 matched control subjects. They also caution about reliance on traditional audiometric screening as the sole indicator of middle ear dysfunction.

Conductive hearing loss and language/learning function. Freeman and Parkins (1979) discuss the implications of otitis media for development of communication and education skills. They suggest two possibilities: (a) disease-induced, intermittent conductive hearing loss results in delayed acquisition of listening strategies necessary for linguistic processing, or (b) deviant physiological development in the central auditory nervous system prevents normal processing of auditory stimuli. Ling (1972) also discusses the probability that children with even mild hearing loss as a consequence of otitis media will experience deficiencies in speech reception due to lack of efficient listening strategies.

In his comprehensive article "The effects of conductive hearing loss on auditory function," Katz (1978) reviews

numerous studies carried out by himself and others where conductive hearing loss was associated with auditory processing difficulties and learning disability. He discusses work using delayed auditory feedback (DAF) speech tasks where subjects with a conductive loss evidenced more severe disruption in their speech under DAF conditions than did subjects with sensorineural hearing loss, normal hearing or normal hearing blocked with earplugs (Butler and Galloway, 1959; Harford and Jerger, 1959). Katz interprets these results to indicate a brain rather than retrocochlear dysfunction (i.e. deficit at a cortical level versus VIII cranial nerve or brain stem system) since interference between normal and delayed feedback would have reduced the DAF effect. However, the case for Katz's interpretation is weakened by examination of the validity of the studies themselves. Because subject populations are small, as are the differences in performance between identified groups, one must question the generalizability and clinical significance of the findings. A conclusion regarding a source of dysfunction based on these findings is premature.

Katz (1978) also reports a study comparing the auditory perceptual performance of learning disabled children with conductive hearing losses with learning disabled children with normal hearing and with sensorineural hearing losses (Katz and Illmer, 1972). The children with conductive hearing

loss performed most poorly on tasks of phonemic synthesis, speech figure-ground, and response to rapid commands. Katz notes that most of the conductive losses were slight to mild in severity and the stimulus presentation was adjusted to individual hearing levels for all subjects.

Analyzing the kinds of errors made by persons with conductive hearing losses, Katz (1978) states that reversals of two-item sequences are frequently noted on material such as the Staggered Spondaic Word Test (SSW) (Katz, 1977), where word order transpositions occur. He observes that this type of error is also common for patients with lesions in the frontoparietal or anterior temporal cortical regions. Katz cites an unpublished report (Andraws, Pinheiro and Moore, 1974) which found evidence of lower amplitude electrophysiological responses associated with this type of reversal error when measurement of averaged evoked responses from temporal region sites was obtained during diotic stimulation. Katz concludes his review by stating that "the above results suggest that the mechanical problem produces nonmechanical abnormalities that may result from cerebral dysfunction. . . ." (1978, p. 885). He goes on to say,

> Disruptions in auditory perception and language (presumably cerebral functions) are associated with fluctuating hearing loss, especially unilateral problems and with early age of onset. . . . Even after the mechanical blockage has been removed, abnormal auditory function may persist. . . . (p. 885)

Deficits in the communication skills of children with a specific history of otitis media are indicated in the findings of studies of unique populations. Disadvantaged populations have received attention due to the higher incidence of otitis media in these groups. Lewis (1976) examined speech hearing in quiet and noise contexts, phonemic synthesis, dichotic listening, verbal and nonverbal intelligence in a group of Australian aboriginal children with a history of otitis media. This group obtained depressed scores on all measures when compared with control groups of aboriginal and European children with normal auditory status. However, statistically significant differences were found only in the auditory discrimination, phonemic synthesis and verbal intelligence tests. Lewis determined that the extent of these deficits was not related to the severity of the acuity loss in terms of pure tone thresholds. He postulated that this disease condition contributed to the development of inefficient listening strategies.

A 10-year longitudinal study of a cohort of Eskimo children has been reported by Kaplan, Fleischman, Hener, Baum and Clark (1973). They found that children who had experienced middle ear disease prior to two years of age, with resultant conductive hearing loss or normal hearing with a conductive component (air-bone gap) had deficiencies in their verbal abilities. The children with acuity loss above 25 dB were deficient in reading, mathematics and

language skills. The authors also found correlations between anomalous tympanic membranes, reduced auditory acuity, low verbal and achievement scores and the number of episodes of otitis media.

Similar effects of otitis media on language and learning performance have been observed in populations of children from middle class socioeconomic groups. Holm and Kunze (1969) administered a battery of standard language and articulation tests to a group of 16 children between the ages of 5-6 to 9 years who had a documented history of otitis media with onset before two years of age. A control group matched for age, sex and socioeconomic status was used. They found delayed acquisition of the skills required for adequate performance on the test battery for the experimental group accompanied by significantly depressed scores on auditory processing and verbal production tasks. The authors speculated that the dysfunctions exhibited by the otitis media group might be due to reduced auditory stimulation during early developmental periods critical to communicative function.

In a further development of this investigation, Zinkus, Gottlieb and Schapiro (1978) attempted to outline a pattern of auditory processing deficits for children with otitis media. This carefully controlled study compared the performance of two groups of children with histories of severe or mild otitis media during the first three years of life. Severity was determined by the frequency of

infectious episodes and amount of medical intervention needed, including surgery. Results indicated significant differences between the groups, with the severe group showing delays in speech/language development, specific intellectual deficits in areas requiring auditory processing skills, and deficiencies in the academic areas of word decoding and spelling. Hearing loss during a critical speech and language developmental period was again discussed as a possible source for these revealed dysfunctions.

While the studies cited in this section suggest a relationship between otitis media and communication disorders, the nature of that relationship has not been conclusively demonstrated. As Ventry (1980) adamantly points out in his discussion of the Katz (1978) article, most of the published work in this area is methodologically flawed. Such factors as size of populations, control of extraneous variables, treatment and reporting of data have been imperfectly handled to varying degrees in most of the extant literature. In addition, replicative and follow-up studies are not in evidence. Thus a causal, or even correlational, relationship between otitis media and communication disorders has not yet been defined.

Sensory Deprivation and Critical Periods

Many of the authors of the studies cited in the previous section have suggested an association between language and

learning disabilities and the pathological condition of otitis media due to sensory deprivation occurring during critical developmental periods. Some have postulated a resulting neurophysiological dysfunction as a source of disruption remaining long after remediation of the pathology.

Northern and Downs (1974) support the theory of a critical period for development of auditory processing skills. They define the concept as,

> . . . certain periods of development when the organism is programmed to receive and utilize particular types of stimuli, . . . subsequently the stimuli will have gradually diminishing potency in effecting the organism's development in the function represented. (p. 71)

They refer to Lenneberg's (1967) work which established a critical period for language learning as terminating at puberty when, he posited, cerebral lateralization was completed. A recent analysis of research since Lenneberg's work (Krashen, 1970) modifies this theory. Krashen shows that evidence for completion of cerebral lateralization by five years of age can be found (Kershen and Bershman, 1972; Berlin, Hughes, Lowe-Bell and Berlin, 1973). He does support Lenneberg's contention that language learning changes at puberty, but attributes this demarcation of the critical period to a change in cognitive style.

Since the time period which appears to be significant in the detrimental effect of otitis media on linguistic competence seems to be the first two to three years of life, the disturbance must involve perceptual or cognitive

operations which are fundamental to the entire auditory learning process. The possibility of an auditory perceptual deficit disrupting acoustic analysis, suggested by Tallal (1978) and Menyuk (1977), finds support in the literature.

Describing her studies of response to sound by human newborns, Eisenberg (1976) reports similar findings to those of Tallal and Menyuk, that is, that the temporal characteristics of auditory stimulus frequency and duration are the primary factors influencing infants' overt auditory behaviors. Her electrophysiological measurements of habituation to auditory stimuli showed differences between auditorily normal and at-risk infants. Eisenberg discusses these findings in terms of inappropriate inhibition or facilitation of feedback systems which operate maladaptively during development, evoked by a biochemical agent. Dempsey (1977) also feels that poor performance on central auditory processing tasks such as binaural fusion and low-pass filtered speech discrimination may result from a biochemical dysfunction of neural transmission occurring at brain stem and cortical levels. Mercher (1978) postulates nonspecific minimal brain dysfunction caused by an endrocrine disorder, hyperthyroidism, which can also produce a condition of otitis media by causing adenoidal blocking of the eustachian tubes.

Katz (1978) whose evidence for a nonmechanical cortical factor in the effects of conductive hearing loss is discussed in a previous section, describes results of deprivation

studies with animals as support for location of the dysfunction in brainstem and cortical systems. He suggests that where deprivation occurs early in life, maldevelopment of such structures is probable.

Webster and Webster (1977, 1978) found morphological substantiation of maldevelopment resulting from both sensory deprivation and specific conductive loss. Using populations of mice, the Websters created conductive hearing loss during early developmental periods through surgical destruction of the external auditory meatus. Another group of mice was raised with avocal mothers under sound restricted conditions. Histological comparison of the brainstem structures of these mice compared to a group raised under usual laboratory conditions revealed differences in the size of certain neurons in the ventral cochlear nucleus and medial nucleus of the trapezoid body. Moreover, deviations in these structures were similar for both the sound deprived and hearing impaired groups (Webster and Webster, 1977)

A further development of this study (1978) looked at cross sections of auditory cell groups from these same populations. In addition, a "reversal" group was used in which a group of mice, after being sound deprived for 45 days, was placed in normal laboratory conditions for a subsequent 45 days then compared to a 90-day, normally raised group of mice. In all cases, no abnormalities could be found by qualitative examination of inner ear structure. Rather, the abnormalities were found in the brainstem

characterized by reduced neuronal size for a variety of cell types within the ventral and dorsal cochlear nuclei, superior olive and medial nucleus of the trapezoid body in the 45-day, sound deprived and hearing impaired groups when compared to normal controls. Differences between the experimental groups were not found. In the 90-day revereal group, smaller neuronal structures were found in the ventral cochlear nucleus, superior olivery complex and inferior colliculus when compared with the normal control group. The 90-day experimental group's histological deviancies were similar to those of the 45-day experimental groups. No neuronal size differences were found between the 45-day and 90-day normal groups' brainstem structures.

The Websters conclude that their data suggest, "that for most brainstem auditory nuclei, normal maturation is dependent on adequate acoustic input . . ." (p. 19). They posit that the indicated critical period for maturation is related to plasticity of the immature nervous system. They cite other animal studies which found behavioral and neurophysiological evidence of abnormal central auditory functioning following induced conductive hearing impairment (Tees, 1967, Batkin, Groth, Watson, and Ansberry, 1970; Clopton and Silverman, 1977). The authors extend their conclusions to suggest a consistency with findings of deficits in human central auditory functioning subsequent to early chronic otitis media.

Neural Substrates of Auditory Perceptual Function

An electrophysiological study by Salamy, McKean and Buda (1975) did indicate changes in human brainstem evoked responses to auditory click stimuli with increased age. Increased wave form definition and decreased response latency were found with maturation from birth to adulthood. The adult pattern appears to be essentially attained at approximately 2·6 years of age. Brainstem evoked responses in infants is shown to be more variable to stimulus intensity and presentation rate than in adults.

The maturational changes found to occur in normal brainstem evoked response and the neuronal anomalies resulting from sound deprivation, which have been delineated in the foregoing section, have further implications when the factor of incomplete myelination of more central auditory processing areas at birth is considered (Dunn, 1977).

It is difficult to find conclusive discussion of the role of the various components of brainstem structure. Neural relationships between the various nuclei have been explored, and both direct and indirect efferent and efferent connections are described (Sanders, 1977; Zemlin, 1968; Davis and Silverman, 1970). It appears that the brainstem is a perceptual mechanism. That is, it is active in the elaboration and transformation of acoustic signals arising from excitation of the acoustic nerve. Webster and Aitkin state,

> We would like to speculate that the ventral cochlear nucleus and the core of the auditory pathway to which it is eventually connected--superior olivary nuclei, central nucleus of inferior colliculus, ventral nucleus of medial geniculate body, and area AI (first auditory field)--form a pathway primarily connected with auditory perception. A second pathway--involving DCN, the nuclei of the lateral lemniscus, parts of the inferior colliculus (possibly including the external and paricentral nuclei), the medial division of the medial geniculate body, and the secondary auditory cortices--may be concerned with nonspecific acoustic features and may be the origin of acousticomotor connections. (1975, p. 334)

Eisenberg (1976) describes the neural mechanisms of audition as appearing to be organized for pattern analysis of the temporal characteristics of acoustic stimuli. She makes the connection between this system and language by stated that "all language sounds can be defined simply as multidimensional patterns that vary in the time domain . . . within known parameter limits prescribed by the apparatus. . . ." (p. 31).

Abnormality in brainstem structure and/or function could certainly result in difficulties in dealing with the temporal characteristics of stimuli such as the frequency and duration of acoustic events. A primary point of disruption in such difficulty would occur during initial awareness and tuning in to acoustic stimulation (Brumer, 1961). Effective processing of acoustic information requires attention to differentiating and relevant cues within an environment of ubiquitous sound. Current knowledge places the responsibility for such activation and selective attention

on brainstem and cortical structures having intimate anatomical and physiological associations with those areas where damage due to recurrent middle ear disease has been documented in animals and proposed in humans.

The reticular activating system appears to control attentional processes both by facilitation and inhibition. The reticular formation has been located morphologically from the level of the medulla superiorly to the level of the thalamus (Brodal, 1958; Brown, 1976). Luria (1973) describes this system as both an activating and regulating agent for the cortex, acting to provide transformed stimulus information for cognitive organization and to modify that stimulation in accordance to cortically-directed responses. This vertical organization of structure implies disruption of higher processes resulting from deficits at lower structural levels. It may be that deviant morphology in lower brainstem neurons, particularly those involved in binaural fusion and localization of sound, results in dysfunction in attentional responding manifested by increased response latencies and errors resulting from an incomplete data base. This kind of deficit would predict the effects of ISI and stimulus duration on auditory responding described in studies with learning disabled and hearing impaired children such as those cited previously (e.g. Tobey et al., 1979; Tallal, 1978; Friedlander, 1970).

Psychological Theories of Attention

The literature of cognitive psychology, neuropsychology and psychophysiology is filled with polemics concerning the existence of attention, its relationship to arousal, activation and effort, its nature as a mechanism, stage or process, its role in the effectiveness of human performance. The function of attention in the interaction between an human organism and its environment can be directly related to that organism's stimulus management activities. In the literature, this function is usually subsumed under the rubric of selective attention. The term implies an act of differential interaction with one's exogenous and endogenous environment.

Attention and information processing. One approach to the concept of selective attention is to view it as a component of an information processing paradigm. In this context, selection might occur at onset of stimulation, at access to memory store or during response organization. It may be governed by the structure of both external and internal factors.

Broadbent (1958) postulated a theory which located a selection filter at a preprocessing buffer. Only stimuli passed by the filter are channeled into conscious analysis. Rejected stimuli decay within the preprocessor, usually unanalyzed and unnoticed by the processor. The information to which the processor responds is received only through

a filtered channel that may be flexibly tuned to different stimulus parameters and switched between input sources.

Studies such as those by Moray (1959) and Treisman (1960, 1964) brought about a qualification of the filter theory. These investigators found evidence that subjects noticed verbal events occurring outside the filtered band width set by experimental task instructions. These findings led to development of a modification of Broadbent's theory into Treisman's version of attenuation. According to this theory, selection still occurred at stimulation and by flexible filtration which, however, could admit non-target stimuli that were of general import to the processor or bore some close relationship to the target stimuli.

A theory based on the work of Deutsch and Deutsch (1963) and Norman (1968) proposes that attention is allocated at the point of response organization. Until that processing level is reached, the perceptual system analyzes and temporarily stores all incoming information. According to Norman (1968), the information selected out of the stored analysis for response is processed to a deeper level which results in its long-term storage in memory. The availability of all information up to the time of response decision is illustrated in a study by Lewis (1970) who used dichotically-presented word pairs, where the non-target member of each pair was sometimes a synonym or antonym of the target word. Semantic similarity between paired words increased the time it took for subjects to repeat the target word. Conversely,

when the non-target word was the opposite of the target word, reaction time decreased. Recall for the non-target words was poor.

Keele (1973) discusses a study by Treisman (1971) where results of a verbal attention-switching task gave evidence of selection occurring both at the stimulus and response levels. Picton, Campbell and Baribeau-Braun (1978) use the ideas of stimulus set and response set as presented by Broadbent in 1971 to explain the results of a number of studies by Picton and his associates using averaged evoked potentials (AER) as the dependent variable. Their results indicate that selective attention can, in fact, occur both early and late in the information processing episode. They find evidence of attention to stimuli, manifested as increased negative wave amplitude at approximately 50-100 milliseconds following stimulus onset (N_1). This wave seems to correspond to reduction of uncertainty after which an appropriate response can be selected. The amount of wave enhancement evidently corresponds to the amount of certain information obtained. The authors suggest that this response may reflect "a comparison between incoming information and endogenous memories and expectancies" (1978, p. 459).

The above explanation of electrophysiological events is similar to the theory explicated by Neisser (1967). Selective attention, from this theoretical viewpoint, occurs as a function of the construction of a percept based on both exogenous (sensory stimuli) and endogenous (memory) information

This synthesis of incoming and stored information is the outcome of a dynamic feedforward/feedback system which precludes the need for a stage- or level-located attentional event. This theory of analysis-by-synthesis has many similarities to the neuronal model of the orienting response proposed by Sokolov (1963). Neisser also attributes the transience of memory of the unattended information to the lesser degree of processing it receives and provides further experimental evidence of lessened attenuation of stimulation based on physical cues and automaticity of processing.

Selective attention models. Another question in the exploration of selective attention is that of determining how much attention can be allocated to a task and in what manner. Here, attention is viewed as an on-going process rather than a discontinuous stage or level. The inability of subjects in many studies to perform well on a dual-processing task, and the demonstrated ability of others to accomplish seemingly conflicting tasks in divided attention experiments, particularly following practice, have generated controversies regarding the use of serial versus parallel processing of information models and the attentional capacity limitation concept.

Broadbent (1958) saw information processing as occurring in a serial fashion and limited to a single channel. He granted the apparent simultaneous processing of events, but

explained it in terms of a time-sharing or multiplexing procedure which involved switching attention between limited, filtered channels.

Both the Deutsch and Neisser theories subscribe to a serial-processing of information model which occurs during the selection of an appropriate response. They view the response decision process as a limited capacity 'bottleneck.' According to their positions, pre-attentive processing can occur in parallel, since selective attention is not activated.

Kahneman (1973) points out, however, that research evidence does not fully support the predictions for attentional task performance of any of these theories. Morey's (1959) study gave evidence of parallel processing shown in changes in reaction time on a dichotic listening task. Some of Treisman's work indicates that attention can be biased to a single channel by task instruction (Treisman and Riley, 1969). Kahneman proposes the concept of limited capacity for attention as determined by the effort expended in task performance. He suggests that processing may occur in a serial or parallel manner, stating

> . . . the main prediction from an effort theory is that the ability to respond to simultaneous inputs should depend primarily on the demands of the activities among which attention is to be divided. (p. 142)

He cites studies by Lindsay, Taylor, and Forbes (1962), and Lindsay (1970) in which parallel processing of stimuli was possible in a judgment task when the stimuli were

easily differentiated, but interfered with the information imparted in multiple judgments when stimulus similarity was increased. Perception of task difficulty is seen by Kahneman as one factor in an internal model of attention allocation; the other factors include nomothetic and decisional variables as well as arousal level.

Norman and Bobrow (1975) also view selective attention as a limited capacity process. They hypothesize that processing can be impaired by limits in either the data or resources available to the processor. The resources available to that processor are finite and reduction of resource below some task-defined level will result in a "graceful degradation" of performance. Because of interaction between processes in relation to the central resource capacity, interference effects can be elicited by contingency controls such as task instructions and processor strategies. The authors state that resultent low priority tasks will be resource limited since attentional capacity will be attenuated through allocation to the high priority task whose only limits, given sufficient attention, will be data-dependent. They point out that the need for resource capacity can often be reduced with performance practice. They suggest several ways in which practice may increase processor efficiency, such as elimination of processing steps or discrete tuning to relevant stimulus dimensions. Reduction in resource demand lowers the threshold for data limited performance and also results in the improvement in any subsequent processing sharing the same central capacity.

Pribram and McGuiness (1975) relate the concepts of selective attention and limited capacity to neurological function. They propose that the attentional system used by an organism to process information is comprised of behaviors of arousal, activation and effort originating from both cortical and sub-cortical levels. Selective attention is defined as application of effort to control information processing channels in order to increase processing competence. This competence is likened to elaboration of a neuronal model. It is attained through decreasing the arousal-induced channel equivocation by effortful reduction of noise and redundancy both within and between channels. Thus, the change that occurs in the information processing operation is not in the information itself, but rather in the neurophysiological context in which it takes place. Practice serves to increase competence by further reducing the neural complexity necessary for task performance. Increased sophistication yields more available channel capacity.

Identification of Auditory Selective Attention in Children

Efforts to identify and measure the auditory attentional response are occurring at both the physiological and cognitive behavioral levels. Much of this work is done with either adults or infant subjects. At present, there is little information in the literature concerning the

normal development of auditory attention skills [illegible] infancy.

Physiological measures. Workers in a diversity of fields have begun to try to measure and quantify auditory selective attention performance using newly developed electrophysiological instrumentation and techniques, particularly in the analysis of cortical responses to sensory stimulation. However, very little of this kind of information is available concerning the young, communicatively developing child. For instance, there is a paucity of normative data regarding the development of basic auditory evoked responses (AER). This lack is based partly, no doubt, on insufficient understanding of the phenomenon of AER and its neurological substrates. However, it must also be at least partially attributable to the anticipated difficulty of obtaining this type of measurement with this particular age group.

Two studies by Barnet, Ohlrich, Weiss, and Shanks (1975, 1977) provide us with some information on the development of AER in children. The first of these studies was a cross sectional study in children aged 10 days to 37 months, while the second was a follow-up longitudinal study with children from birth to three years of age. The cross sectional study used 130 children tested during natural sleep. As in most studies of auditory evoked potentials, sets of auditory clicks were used as stimuli. Results of the

analysis of measured AER latencies and amplitudes revealed varying rates of change in AER latencies which suggested to the authors that the underlying neural structures represented by these components were at least partially independent of each other in their development. Changes which occurred were greatest during the first year of life when variance was also highest. With the exception of the N_1P_2 wave, amplitude of the AER waves increased. In the longitudinal study using only 16 children, with a wide range of variance between subjects in terms of degree of change, latencies of the AER later-appearing components decreased while amplitudes increased. Most of the variance was accounted for by age, sleep state and subject factors other than sex and rearing/race milieu. Greatest amount of change occurred during year one. The results of this study, then, were in agreement with earlier data obtained from the cross sectional sample.

Another developmental study by Miyazaki, Mori and Kahigi (1975) indicates a finding conflicting with the above studies. In this rather brief report, both visual and auditory evoked responses were discussed. The population was composed of two groups of 11 subjects each; one group with a mean age of 5.6 years and the other of 18 years. The stimulus used was, again, an auditory click. Findings indicated decreased amplitude of AERs for the older group. Unfortunately, very little technical information is given in this report, so the source of the conflicting findings is

not readily apparent. Information concerning rate and intensity of stimulus presentation as well as more specific designation of the active lead placement or, for that matter, the method used for averaging and analysis of the data might be instructive in determining the reason for this seeming reversal of AER development. Indeed, no specification is given concerning which particular components of the AER were considered. Nor was any detail regarding instrumentation, and especially filtering, available in order to facilitate interpretation of these results.

A search of current literature concerning electrophysiological measurement of attention to auditory stimuli reveals that the bulk of this work has focused on either adult or infant subjects. Much of the work done with infants is completed while the subject is sleeping (Berg and Berg, 1978). While this method measures behavior in a very typical infant state, it does present some difficulties in applying any interpretation of those results to that of a preschool or early elementary age child whose usual state is certainly not sleep and whose electrophysiological responses appear to more closely resemble those of an adult (Barnet et al., 1975, 1977). Again, one cannot feel confident in extrapolating the results obtained in a population of adults engaged in a complex auditory task to the auditory behavior of a five year old child. However, there have been a few studies which have looked at some aspect of attentive behavior to auditory stimuli in the young child

using a form of electrophysiological measurement. The populations considered are typically ones defined as deviant in some way with use of a control group of children identified as "normal." A review of several such studies follows to illustrate the methodologies which can be employed in this measurement.

Mulcahy and Das (1977) considered attention to auditory stimulation using pure tones, words and CVC nonsense syllables by monitoring the habituation of galvanic skin response (SCR) and heart rate (HR) orienting responses to repeated stimulus presentations. The habituation procedure was one which the authors had used previously and labeled "semantic satiation," which involves a massed presentation of the designated stimulus before habituation testing is performed. Subjects were two groups of males, 36 ten year olds and 36 college undergraduates. Results revealed that the SCR frequency and magnitude was significantly smaller for stimuli given by massed presentation and that SCR did habituate over trials. No such findings were observed for HR. For both children and adults, CVCs received the largest magnitude SCR response. Finally, children's SCR frequency was greater than adults' was. The authors suggested that SCR and HR can be used to measure attention to meaningful stimuli. They used Sokolov's (1963) neuronal model theory to suggest that the larger response to the nonsense stimuli (CVC) was due to its complexity and the need for more trials to

form a model than for the more familiar words or simpler pure tones. They discussed another study that they had completed with a group of subjects identified as mentally retarded who had longer habituation patterns to both CVCs and words.

Also in 1977, Zambelli, Staurm, Martinsky, and Loiselle reported the results of a study they completed where they observed the auditory evoked potentials of adolescent boys described as hyperactive with prior identification as experiencing minimal brain dysfunction (MBD). Subjects in this study were nine boys described as above, with nine matched controls with no such identification. The median age for both groups was 14.4 years. The boys were presented with a selective attention task consisting of a series of auditory tone pips. They were required to discriminate sporadic higher pitched stimuli, keep count of them and report the number to the examiner at the end of each trial. Response correctness and reaction time was scored for the last two trials as a behavioral measure. This study found enhancement of the N_1 wave at signal onset for the control group but not for the MBD group. The MBD group evidenced significantly more errors than the controls on the behavioral measure, with a preponderance of errors of commission (false hits). The authors felt that this study gave support to a theory of maturational lag in MBD syndrome, but did not rule out the possibility of dysfunction of the frontal association cortex.

Other studies have used various combinations of electrophysiological measurements to describe some aspect of auditory attending behavior. Gruenewald-Auberbiew, Raschl and Netz (1977) analyzed the electroencaphaiographic responses to mixed modality stimulus pairs of twenty-one 12 to 13 year old children. Specifically, contingent negative variation (CNV) and alpha attentuation behavior were observed in both simple and discriminative warned reaction time tasks for children placed in one of three groups ranked on ability to concentrate (i.e. high, medium, low). Significant differances between groups were obtained, with the group rated highest in their ability to concentrate demonstrating increased alpha attenuation and CNV during the ISI for both reaction conditions. No direct relationship between the two EEG measures during ISI was found. The authors hypothesized that "this is an expression of the greater amount of concentration or 'effort' . . . which these children invest in the experimental task" (p. 45).

Lawler, Obrist and Lawler (1976) used various cardiac and somatic response electrophysiological measures during reaction time task where both uncertainty and motivation were manipulated. Twenty-five fifth grade boys and 25 male college students participated in a choice reaction task where a warning light with varying predictor values was followed by a 700 or 1K Hz tone. Measurements included heart rate (EGG), chin and forearm (EMG), eye blinks and movements (EOG) and general body movement. Findings were

that HR and response certainty had an inverse relationship; that HR, EMG, EOG and body movement did correlate with changes in motivation; and that these relationships did not differ significantly between the two groups. The children did exhibit a generally high level of tonic activity while adults showed faster reaction time and less slowing of reaction time with uncertainty than did the children.

Some other studies can be found in the current literature where experimenters attempted to use some measure of electrophysiological behavior to get information concerning children's attention to and processing of auditory information (Rugel and Rosenthal, 1974; Rugel, Chestam and Mitchell, 1978; Johnson, 1977, Fuller, 1975). Methodological coherence is extremely low in this area however. Terminology regarding such concepts as "attention" and "arousal" is vaguely specified, identification of target populations is varied and rationale for use of particular combinations to tasks and measures is non-existent. Additional information regarding cortical response to auditory stimuli is available in the literature regarding use of AER and brainstem evoked responses (BSER) for measurement of auditory acuity and functional integrity (Northern and Downs, 1974). This work is not aimed specifically at attentional measures, nor is much information available on work with young children. It does, however, illustrate wave forms obtained and techniques available for recording this type of response.

In a position paper based on his doctoral research, Sabet (1978) discusses the problems extent in the electrophysiological measurement of AER in selective attention performance. He points out that a common design problem in many selective attention studies is that the independent variable, attention, is often implied through use of task instruction rather than design controlled. In addition, he discusses the difficulty for interpretation of results regarding the dependent variable when the laboratory context often used in psychophysiological work is atypical of real life situations. That is, changes in AER to short bursts of auditory click stimuli may not allow a workable analogue to the sustained attentional performance needed for processing longer, meaningful speech sequences. Sabet also indicates that AER measures of amplitude only may not be as reliable a measure of attentional performance as a combination of both amplitude and variance of AER's.

Alternative measures of auditory attention. Use of physiologic measurement instrumentation with young children is difficult. Because of the sensitivity required for accurate measurement, physical movement must be restricted. Moreover the appearance of the instrumentation, electrodes, wires and the like, as well as its location in laboratory settings, very often contribute to negative attitudes concerning participation on the part of very young subjects. Some investigators have employed other methods of observing auditory attentional behavior in young children.

Shadowing tasks have been used to study auditory attention behaviors in adults and children. Flaherty and Coren (1974) used reaction time as a measure of the effect of attention to auditory stimuli. Adult subjects were required to emit a key-press response to semantic (monosyllabic words) and pure tone (1, 2, and 3K Hz) target stimuli embedded in a list of dichotically-presented digits recorded at randomly varied intensities. In two of the three test conditions (balanced for ear laterality), the subjects were to verbally repeat (shadow) the digits they heard in one ear and were told that this was their primary task. For the third condition, no verbal shadowing was required, with the key-press response being defined as a divided attention task. Results revealed increased latency of reaction time to targets in the nonattended channal, with no significant differences in reaction time between the shadowing and divided attention tasks. The authors felt that this finding supported an attenuation model of auditory attentional function. Another finding of this study was that reaction time latency increased for semantic stimuli relative to tonal stimuli. It was postulated that this result demonstrated that additional processing was necessary for the semantic stimuli, and that this processing was a factor in observed attentional effects.

Use of a shadowing task for examination of the effects of auditory attention in children permitted Andresko (1977) to compare the performance of groups with and without

learning and reading disabilities. Tasks were to shadow dichotic prose material both with and without a competing message of similar material. The disabled children had more difficulty with the shadowing task, particularly when a competing message was present. They began sooner to make more errors than did a group of children designated as good readers. Analysis of the effect of ear laterality indicated that the disabled children did not demonstrate a right ear advantage in their shadowing performance.

Other measures relevant to auditory attentional behavior. Except for the studies cited above, most of the work which examines children's performance in processing of auditory stimuli does not directly address the question of the effects of attention on that performance. However, some test designs implemented and results obtained appear to be related to an attentional factor.

The discussion by Tallal (1978) of her series of studies points overwhelmingly to the importance of rapid changes in acoustic stimuli over time in dysphasic children/s ability to discriminate or repeat the stimuli. Tallal's findings indicate that increasing the duration of change cues improves performance for these children. One possible explanation for these findings is that increased cue duration permits more time for analysis following an attentional response in children where a RAS deficit results in a delay of that response. If this explanation is valid, it would predict

increased response accuracy but not decreased reaction time on tasks with steady-state rather than transitional cues.

The study by Tobey et al. (1979), described previously, also showed the difficulty in processing rapidly changing acoustic cues for groups of learning disabled children. In addition to evidencing more difficulty than control children in the overall identification of stop consonant-vowel stimuli presented dichotically, the experimental groups also showed less ability to improve their performance given more time between stimulus presentations. That is, while both groups were more accurate on performance with the second member of each stimulus pair, the control group's accuracy for the first member improved when ISI was increased while the experimental groups showed little difference in their performance. When compared to the results obtained by Tallal, this seems to indicate that increased processing time per se is not sufficient for improving performance with auditory temporal information for these children, but rather that the availability of the information itself (i.e., cue duration) is the necessary condition for improvement.

Again, the studies with time-compressed speech stimuli as well as other tests of central auditory function point to the possibility of an attentional deficit as a factor in poor auditory processing performance. The Test of Central Auditory Abilities described earlier was developed by its authors to assess children's ability to perform a

sentence completion task under difficult listening situations--a diotic competing message and filtered speech (Costello, 1977). The Synthetic Sentence Identification Test, discussed by Keith (1977), taxes the subject's ability to attend to auditory stimulation both by compressing the speech signal and by using both ipsilateral and contralateral competing messages. Results of studies such as those by Beasley and Freeman (1977), Pinheiro (1977) and Atan and Davis (1968) have consistently revealed poorer performance for language and learning disabled subjects described as showing attentional deficits. Dempsey (1977) describes four commonly used tests of central auditory function which employ time-compressed speech, filtered speech and dichotic presentation as tests of processing rate. She interprets results on such tests as indicating the possibility of temporal processing problems related to deficits in selective auditory attention.

Many tests of auditory discrimination, such as the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (Goldman, Fristoe, and Woodcock, 1970), include a subtest in which the listening task is made more difficult by inclusion of masking noise such as a competing speech signal. In such cases, the subject is required not just to discriminate the characteristics of the auditory target signal, but also to selectively attend to that signal in a background of similar non-target stimuli.

Measures of auditory attention in OM children. Unfortunately, studies of children with a specific history of otitis media have not used measures which address themselves either to auditory temporal processing generally or to auditory attention specifically. Lewis (1976) did obtain a rating of attentiveness and reading ability from his subjects' teachers. He found a positive correlation between this rating and performance only with the Wepman Auditory Discrimination Test, and a negative correlation between attentiveness rating and reading ability for these groups. Holm and Kunze (1969) employed tests of receptive and expressive speech and language skills along with identification procedures which included standard audiometric documentation of a conductive hearing impairment. Zinkus et al. (1978) used a battery of tests assessing motor, speech and language developmental levels, verbal and nonverbal psychological abilities, educational skills acquisition.

A study of children with a history of otitis media by Needleman and Menyuk, described by Needleman (1977), found deficits in these children's linguistic capabilities as evidenced in their phonemic and morphophonemic productions in words and connected speech. Although deficient performance on the part of children with a history of otitis media was found for most of these measures, only circuitous reasoning could link these results to auditory attentional ability.

Statement of Purpose

A review of relevant literature indicates that many children who exhibit dysfunctional skills in learning, communication, reading, and social behavior have demonstrable difficulty in processing auditory stimuli. For many of these children, peripheral auditory acuity appears to be intact and central auditory deficits are proposed. Often, deviant attentional behaviors are cited in a description of these children. Explicit assessment of their auditory processing deficits yields evidence of the influence of time-locked acoustic cues on these children's poor performance. A link between the latency of the attentional response and duration of acoustic temporal cues is suggested.

A body of research which gives evidence of long lasting language and learning problems resulting from early recurrent middle ear infection has been described. Support for assumptions of deviancies in brainstem morphology resulting from such a history has been found in animal studies. The anatomical and physiological relationship of these structures with the system responsible for attentional behaviors--the reticular activating system--has been pointed out. However, although a variety of methods for measurement of auditory attentional responses have been developed, none have been used with this population where some documented basis for suspicion of an attentional deficit exists. Study of such a population could yield increased information regarding

the underlying psychological and physiological sources of auditory processing problems.

Although the bulk of published research concerning the effect of recurrent otitis media on children's development of communication skills suggests an association between intermittent conductive hearing loss and language/learning dysfunction, very little definitive information regarding the nature of the association is available. This deficiency is attributable in large part to methodological weaknesses in the small number of studies dealing directly with young children with conductive hearing loss. In response to the pervasive criticism of design factors in this type of study (Young, 1976, Ventry, 1980), a goal of this study was to construct a methodology which would facilitate maximum utilization of the data obtained in this research activity. That is, this study attempted to provide information concerning subject selection, instrumentation, procedures, data measurement and analysis which was more specific and complete for the purposes of critical evaluation and possible replication than is found in the literature that is currently available.

This study was proposed to examine specific behavioral responses to auditory stimuli of a group of children who exhibited communication dysfunction with a documented history of recurrent otitis media in the first three years of life (OM), and to compare their responses to those of a group of communicatively handicapped children with a history free

from recurring episodes of otitis media during the first three years. It was posited that the OM group would show evidence of a specific auditory attention dysfunction when compared to the NOM group and that these attentional deficits could be manifested in situations where difficult processing tasks stressed the child's ability to attend to multiple auditory inputs. Such deficits, exhibited as increased response errors (RE) would differ both quantitatively and qualitatively from those of the NOM group. Further, the possibility that on auditory perceptual tasks where attentional behavior was facilitated, differences in performance between the two groups might be apparent in differential error patterns for the OM group as compared to the NOM group. In fact, that these patterns and/or patterns of stress-related behaviors might serve to identify subtle differences between groups not readily apparent in the error scores. Finally, whether or not differences in test performance existed, the possibility that auditory attentional performance and history of middle ear disease might not be related in a manner which was relevant to further clinical or research interest was posed.

Therefore, the following questions were proposed for study:

1) On a series of tasks which require varied levels of auditory attending behavior for accurate performance, will the OM group exhibit significantly greater fluctuations in RE than the NOM as a function of attentional conditions for each test;

2) does analysis of the errors committed on and stress-related behaviors emitted during auditory attentional tasks reveal differential response patterns for the OM and NOM groups;

3) can OM/NOM group classification be accurately predicted on the basis of RE scores on tests requiring an auditory attentional response demand which can be comparatively defined as being stressed or facilitated?

CHAPTER II
METHODS

Introduction

A primary factor in the flawed methodology existing in the area of auditory processing dysfunctions is the use of descriptive rather than experimental research designs. Ventry (1980) is critical of this type of design, but acknowledges the ethical and pragmatic considerations that determine its prevalence in research concerning pathological conditions such as hearing impairment. In his article, Ventry suggests that more careful control of variables affecting both internal and external validity and the use of stronger statistical analysis procedures would render the results of a descriptive study more credible and useful for further research activity as well as clinical application. His suggestions regarding design components influencing the validity of a study (Ventry, 1980, Ventry and Schiavetti, 1980) as well as those discussed by Campbell and Stanley (1966) were considered in the construction of the methodology and selection of procedures used in this study.

Subjects

Two groups of 12 children each were formed for this study. Individuals were selected from the population available through the University of Florida Speech and Hearing Clinic in Gainesville, Florida. Membership in the groups was determined using seven different demographic variables. For each member of the OM group there was a member of the NOM group matched on the variables of age, sex, race, intelligence and medical history. The total group memberships were matched on the variables of socio-economic status and current therapy program participation. Efforts to match groups on the basis of education were unsuccessful. The individual's history of otic disease was the differentiating classification for placement in one of the two groups.

Group Classification

Subjects eligible for placement in the OM group had a history of recurrent middle ear infections with the first episode and subsequent recurrences presenting primarily within the first 36 months of life. This history was substantiated by scores obtained on a questionnaire completed by each subject's parent (Appendix A). The 25-item form included a request for demographic information from which

socioeconomic status scores were derived and questions pertaining to the subject's general medical history. Also included were 18 closed-response questions concerning the child's history of respiratory disease symptomology, documented medical diagnosis and treatment of middle ear disease, evidence of hearing problems and documented auditory acuity impairment. Questions were paired regarding occurrence of events before and after subject was three years of age. These 18 questions, with weighted response values, were obtained from the revised version of a questionnaire developed by Kessler (1978). Kessler conducted a validation study for this form using parents of subjects with known histories regarding the presence or absence of otic disease (N = 22). Results obtained through discriminant analysis procedures indicated that the weighted response scores were excellent predictors for classification of subjects into normal or early middle ear disease groups. For this study, a response score above 10 on questions relevant to history before age three years (even-numbered questions) was considered a basis for classification into the OM group. This classification was supported by graphic evidence of fluctuations in auditory acuity status (audiograms, tympanograms, etc.) which were available in clinical files.

Subjects placed in the NOM group were those with a score of less than 10 on questions pertaining to otic history before age three years and the existence of at least two

audiometric measurements indicating auditory thresholds within normal limits.

Family physician information was obtained with the intention of verification of otic disease history. However, for over 65% of the children screened for this study, the current physician was not the clinician involved in that diagnosis/treatment. Most often, these practitioners were inaccessible to this study by virtue of parents' lack of recall of names, addresses, dates, etc. It was therefore decided that questionnaire response scores and graphic evidence such as that described above would provide sufficient documentation of middle ear disease history.

Communicative Status

All subjects participating in this study were free of evidence of otic disease at the time that research task administration took place. This was defined by audiometric measurement obtained on the day of the subjects' participation in the study procedures. Measurement took the form of otoscopic inspection of tympanic integrity, tympanometric evaluation of middle ear function using an American Electromedics Model 85AF tympanometer and pure tone air conduction threshold assessment of frequencies 250 Hz through 4K Hz at 25 dB SPL (ANSI 1969) using a Grason and Stadler GSI 170i Clinical Audiometer. A pure tone average (PTA) was derived based on responses at 500, 1K and 2K Hz.

All subjects were judged to have communicative deficits which were evidenced by the written clinical opinion of appropriate professionals and supported by generally acceptable performance measures such as standardized speech or language tests administered within six months prior to research task performance. Group membership was balanced for the number of subjects who were/were not currently receiving clinical intervention for their observed communication deficits. In each group, four members were currently enrolled in a speech/language therapy program while eight members were not. All subjects came from environments where English is the native language.

Age

The age range for subjects in this study was 51 months to 89 months. Subject pairs were matched within six months of each other's age. For this study's area of interest, there is a scarcity of information on this age group (Rapin, 1979). However, the lower age limit was chosen with regard to pragmatic considerations concerning ability to maintain interest and meet task demands while the upper limit was set in response to conflicting findings regarding the diminishing of performance differences in older children, also reported by Rapin (1979). The mean age for each group was 66.5 months for the CM's and 67.3 months for the NCM's.

Sex, Race

Subject pairs were matched on the variables of sex and race. The study population contained 10 females and 14 males. Two pairs of Negro and ten pairs of Caucasian children participated in the study.

Socioeconomic Status

Although there appears to be an increased prevalence of otitis media in disadvantaged populations (Northern and Downs, 1974), there is some evidence that socioeconomic status (SES) is not a differentiating factor in the linguistic deficits of children with a history of middle ear disease (Needleman, 1977). Nevertheless, group membership was balanced for this variable using the criteria established by the Four Factor Index of Social Status (Hollingshead, 1976). Information was derived from the Parental Questionnaire (Appendix A). The social strata described by Hollingshead (p. 27) were identified as five levels, 1-5. The mean SES for each group was 2.4, OM's and 2.0, NOM's.

Intelligence

All subjects achieved a non-verbal intelligence score at or above a normal range as measured by the Columbia Mental Maturity Scale (Burgemeister et al., 1972). Subjects were pair-matched within one stanine level of each other.

The mean score for each group, expressed as a stan[illegible]
5 (OM = 5.5, NOM = 5 8),

General Medical History

Subjects had no observed or reported behavioral, visual or other physical difficulties which would interfere with their ability to perform task requirements. Medical histories were unremarkable as concerns prolonged hospitalization or chronic medication except for episodes connected directly to the existing communication handicaps (e.g. surgery to remove tonsils/adenoids).

Education

For subjects attending school, only subjects whose grade level was appropriate for their chronological age were selected. The optional attendance of a preschool program was a factor which was not controlled in this study. In the OM group, 10 subjects were enrolled in some type of preschool or school program while in the NOM group only seven subjects were so enrolled.

Measurement

Materials

Tasks were devised using both standardized and non-standardized materials. The tasks employed were categorized

in terms of stressed attentional demand (ST) or facilitated attentional demand (FC) required for accurate performance. One measure was also defined in terms of right or left ear stimulus presentation

As was discussed previously, the literature concerning attention contains extensive theoretical discussion on the nature of attention as well as the neurophysiological realization of the attentional process. Each discipline involved in this discussion has developed its own experimental approach to observation of the act of attending. The tasks required by these researchers vary substantially in terms of the sufficiency of their theoretical base, affecting the validity of an instrument as a measure of attention Furthermore, some task requirements are such that their use with children or with dysfunctional subjects is inappropriate. The tasks used in this study were selected with these problems in mind

Choice of tasks employed was made in consideration of the focus on an identifiable aspect of attentional behavior, the appropriateness of the task for the age and communicative function of the subjects and the availability from previous research of information concerning children's performance on these or similar tasks.

Selected tasks employed real speech stimuli. Sabat (1978) points out that use of non-speech stimuli can create problems in interpretation of data due to such factors as the difference in informational content between successive

words as opposed to auditory tone pips used as cues, difficulties in maintaining subject interest and, subsequently, performance using non-speech stimuli; non-generalization of performance results to general and clinical behaviors when using non-speech stimuli.

The attentional tasks can be structurally delineated using the parameters described by Garner who states,

> If a subject succeeds in selectively attending, he has in some sense managed to treat two or more sources of information as independent. However, the sources themselves may or may not provide independent information, so the independence of information itself becomes a critical part of the experimental question (1974, p. 27)

He outlines five types of tasks:

1) single information source--only one input source is available and necessary for the required task response, useful as a base measure in terms of either response time or response accuracy;

2) attentive selection--subject required to attend to one of two available, independent sources of information; performance on this task should compare to (1) unless selective attending ability is deficit;

3) attentive combination--subject must process multiple sources of information simultaneously, independent information, problems here would imply difficulty either with divided attention, in which case neither source would be processed as well as (1), or selective attending where only one source is processed,

4) attentive integration--subject receives correlated or redundant information from multiple sources; performance should compare favorably with (i), failure implies difficulty with integration of information;

5) various combinations of the above in such activities as concept learning and free classification.

The tasks used in this study are described as they relate to Garner's concepts. Further discussion of these concepts will appear in the discussion of results (Chapter IV).

Four tests were used in this study. Each of these was divided into two subtests which were differentially defined by presentation condition (stressed/facilitated, right/left ear). The four tests from which the subtests were derived are all in common usage by audiologists and speech pathologists for the assessment of subjects with suspected auditory perceptual disorders. Each test was available on an audio tape recording employed in normal testing procedures to ensure standardized presentations. Following is a description of each test and its subtest conditions.

Competing Sentences Test (CS) (Willeford, 1978) Two different sentences dealing with the same topic were presented dichotically. The target sentence was presented at 35 dB SL while the non-target sentence was presented at 50 dB SL (PTA). Twenty sentence pairs from Willeford's List I were used (Appendix E). Order of ear presentation was randomized between subjects (CSLE, CSRE).

The response demand was to repeat the target sentence. Willeford's criterion for recall performance is not

stringent, requiring only a parephrasing of sentence content (1978, p 259) However, based on three years of experience with this test, Dempsey (1977) recommends a demand for accurate verbal repetition and notation of error patterns. She suggests that this test requires a selective attention response about which this modification will yield further information. This modification was incorporated into the scoring procedure for this task This presentation meets the parameters of the selective attention task described by Garner (1974).

The number of sentences incorrectly repeated or omitted were tabulated as a response error score for each ear. Both a verbatim and a parephrased response error score were derived (CSRE/CSREP, CSLE/CSLEP). Responses were then analysed for integration, linguistic, order, laterality and recall patterns apparent in errors of omission, substitution or blending of test elements. Description of the error classes appears below. Subjects were not penalized for articulation errors which were judged by the examiner using a tape recorded baseline speech sample as a reference for usual speech production.

Rapidly Alternating Speech (AS) (Willeford, 1977). Segments of a sentence were presented diotically at 50 dB SL (PTA) alternating between ears in 300 millisecond bursts.

Willeford describes this task as simple even for five year old subjects when the response criterion is lenient

regarding sentence approximation. Dempsey (1977) again suggests that a more exacting demand for response and analysis of errors committed may yield information regarding attentional skills. After observing error patterns that, "seemed typical of children with auditory processing disorders," she suggests that,

> It is also possible that the alternating mode of presentation offers a 'novel' listening situation, perhaps affecting the interaction between reticular activating system and cortex. Children with attentional disorders may be more disrupted during the task as they must learn to focus attention to each ear alternately. Do children who are highly distractible make more errors when the test alternates between ears than when it is presented in one ear? Perhaps this test is sensitive to many variables which we have not been aware of in the past (p. 306)

Test sentences were presented monaurally as a baseline measure, and in the alternating mode. Two lists consisting of ten sentences each, Lists A and B (Appendix E) were used. List B was presented in the alternating mode, designated as the stressed attention condition (ASST). List A was presented monaurally to the right ear only and designated as the facilitated attention condition (ASFC). List presentation order was randomized between subjects. Responses were scored as the number of sentences incorrectly repeated. Responses were scored both for verbatim and paraphrased accuracy (ASST/ASSTP, ASFC/ASFCP). This task

meata tha parametars of tha single information source and attantive intagration taaka dascribed by Garner (1974).

Error pattarns wara analyaad as dascribed for the Competing Sentences Test. Again, subjects wara not panalizad for artioulatios arrors.

Staggered Spondaic Word Tast (SSW) (Katz, 1977). Competing bisyllabic words (spondaas) wara preaanted in a staggered dichotic mode so that tha first ayllabla of tha firat spondae word and tha sacond syllabla of the sacond spondee wara non-compating, whila tha aacond syllable of tha firat apondaa and tha first ayllable of the aecond apondaa were compating for an auditory attentional responae. Tha non-competing sylleblas in aach atimulus item can alao ba elementa of a bisyllebic word not used aa a atimulua item (a.g. ioa land/swaat craam). Tha atandardizad test conaiata of four practica pairs and forty stimulus paira of spondeea. Leading syllablaa ara alternatad batwean aara. Each pair is precaeded by tha cua, "are you raady," daliverad to the leading aar. Subjecta ara requirad to repeat both spondees in each pair of stimulus itams. Raaponaes were scorad for number of arrors and a percentaga was derived for both ordar and aar affects aaparata from tha arror analyaia uaad for tha purposas of thia study. That is, uaual acoring for this test includes a count of the number of arrors as a function of order of syllable presantation (ordar) and leading aar of preaantation (ear). Ordar confuslona ara notad and

recorded, but order confusion of four correct stimuli was not counted as a response error in the raw score.

The standard SSW, List EC (Appendix E) was presented at 50 dB SL (PTA) with the following modifications. Dempsey (1978) states that the two 20-item halves of List EC are well correlated (p. 693). In an attempt to identify the role of attention in subject responses, the cue to the leading ear was eliminated for one half of the 40-item list (SSWST) but remained for the other one half (SSWFC). The order of the cued/non-cued 20-item halves was randomized between subjects. This task meets the parameters of the attentive combination (divided attention) task described by Garner (1974).

Responses were scored for number of errors in each four-syllable stimulus set. Errors were tabulated for both SSWST and SSWFC subtests. Error patterns were determined by considering errors committed on stimuli presented to the left ear as opposed to the right ear (Laterality), by tabulating the number of syllables repeated out of sequence whether correct or incorrect (Order), and by counting the total number of substitution or omission of stimulus items which occurred (Recall). In addition, the response bias information available through conventional scoring of the SSW was noted.

Goldman-Fristoe-Woodcock Test of Auditory Discrimination (GFW) (Goldman et al., 1970). A list of 30 words

(Appendix E) was presented binaurally at 50 db SL (PTA) first in a quiet (GFWFC) then in a competing noise context (GFWST). A vocabulary training procedure preceeded testing. Signal to noise ratio on the noise subtest was +9 dB. Subjects were required to point to one of four pictorial items which best represented the stimulus word. This test meets the parameters of both the single information source and selective attention tasks described by Garner (1974).

Responses were scored in the form of total errors for each subtest. In addition to a percentage error score (GFWST/GFWFC), a percentile score (GFWSTP/GFWFCP) obtained from Appendix C of the test manual (p. 28) was recorded. This test was included to provide a measure of the subjects' response abilities on a non-verbal, closed set task. It also provides an extensive set of performance norms.

Stressed (ST) or facilitated (FC) attention tasks. The tasks described above were identified as ST or FC tasks by means of their fit to Garner's (1974) concepts of single information source as opposed to the attentive selection, combination or integration sources. Therefore, FC tasks included: (a) the monaural presentation of the Rapidly Alternating Speech Test (ASFC); (b) the quiet subtest of the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (GFWFC); (c) and although it is not an exact fit, the cued portion of the Staggered Spondaic Word Test (SSWFC). The ST tasks included: (a) the Competing Sentences Test

(CSLE, CSRE); (b) the diotic presentation of the Rapidly Alternating Speech Test (ASST), (c) the non-cued portion of the Staggered Spondaic Word Test (SSWST), (d) the noise subtest of the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (GFWST)

Instrumentation

Using the master tape recordings for each of the tests, four research tape recordings were generated, using Ampex, Model 602 and Sony, Model TC-3530 tape recorders with the signal routed through a two channel audiometer. Stimuli were altered as described above. Each tape contained all the subtests in a different presentation order (Appendix F). Choice of Tapes I, II, III or IV was randomized between subjects.

Research tape recordings were played on a Sony Model TC-3530 tape recorder with the signal routed through a Grason Stadler GSI 1701 two channel audiometer and presented to the subject through TDH 49p earphones. Subjects were seated in a soundproof booth at a small table. All subject responses were tape recorded using a Shure Model 560 microphone and Panasonic 612 stereo cassette deck recorder.

Procedures

Selection

Information to determine subject eligibility and matching constraints was obtained by researcher interview with children, their parents and other relevant individuals, and by survey of the completed Parental Questionnaire. Screening tests were administered at the time of scheduled research testing appointments. Audiometric testing occurred at the same time. Any subject falling outside the normal limits for auditory acuity was re-tested in one week's time. If a hearing impairment or tympanic abnormality was still evidenced at that time, or if other placement requirements were not met, the subject was dropped from the study and replaced by another.

Tests Administration

Administration of all tests took place during an approximately one and one-half hour session for each subject. In order to attempt to maintain the cooperation of the children used as subjects, completion of each task was tangibly reinforced (token chips) and a premium offered for completion of "the whole job." No reinforcement for adequacy of response was offered except during training procedures which preceeded each test. Children were allowed breaks in the testing procedure, if requested, to allow

physical movement and other possible necessities. Note was taken of the frequency and approximate duration of these disruptions for each subject.

Subjects were seated in an auditorily and visually quiet room (IAC booth) with one examiner. The examiner made written observations concerning nonverbal subject behaviors (see sections on Error Patterns and Performance-related Behaviors below), as well as transcribing the subject's responses to stimulus items. This error transcription was expanded and verified by the examiner by use of recordings of the test session.

Although presentation of the tape recorded tests was controlled by the researcher, all response transcription and accuracy judgments were made by independent examiners. These examiners were four senior undergraduate students in speech pathology, Department of Speech, University of Florida, who were uninformed as to the OM/NOM classification of the subjects. They were trained in the observational techniques and error response notation designed for this study. Examiners were assigned to subjects on the basis of schedule agreement constraints for parent, child, examiner, researcher and audiology suite availability. Inter-judge reliability measures indicated response error and classification agreement to be 90% for error judgments and 78% for error classification. Intra-judge reliability figures were 97% and 90% respectively.

Data Analysis

Response error. Raw error scores were converted to ratio form by dividing the number of errors by the number of stimulus items for each subtest. On the CSLE, CSRE, ASST and ASFC, two sets of scores were recorded (verbatim, paraphrased response). The GFWST, GFWFC scores were also recorded in two forms (percentage error, percentile placement). Both sets of scores were submitted to statistical analysis. The scores for the SSWST, SSWFC 20-item subtests were derived using a multiplier of five as listed on the published test protocol (Appendix E), and following the procedure for R-SSW described in Katz, 1975.

In order to answer the questions posed in this study, the following hypotheses were formed:

I. there is no significant difference ($\alpha = .05$) in the median response error scores between the OM and NOM groups on ST tasks for each of the tests used in this study,

$$H_o - MdRE\text{-}ST_{om} = MdRE\text{-}ST_{nom}$$

II. there is no significant difference ($\alpha = .05$) in the median response error scores between the OM and NOM groups on FC tasks for each of the tests used in this study,

$$H_o = MdRE\text{-}FC_{om} - MdRE\text{-}FC_{nom}$$

Error patterns. For each subject, a pattern of errors was sought, determined by tabulation of errors under specified categories, then calculation of the percentage of

error type as a function of total errors for each subtest. The categories were:

1) Integration of competing items--responses in which components of dichotically-presented items are mixed,

example--CSRE--right ear stimulus "I think we'll have rain today,"
left ear stimulus "There was frost on the ground,"
error response "There was rain today;"

2) Order--responses which confuse the order of stimulus presentation,

example--SSWST--leading ear stimulus "ash tray"
lagging ear stimulus "tin can"
error response "tin can ash tray,"

3) Laterality--the number of errors committed by the total target presentations to each ear on dichotic or diotic tasks,

4) Linguistic confusion--frequently appearing substitutions or omissions in syntax, grammar or semantics tabulated for each subtest,

5) Recall--errors of omission where part of the stimulus was recalled or statements by the subject such as "I don't remember," tabulated for each subtest.

Performance-related behaviors Observations of performance-related responses were also recorded for comparison between subject group classifications and attention demand subtest. These responses included:

1) Latency--a tabulation of responses which were so slow as to overlap with presentation of the succeeding stimulus item, or where no response was made;

2) Confirmation seeking--verbal and non-verbal behaviors implying the subject's need for reassurance concerning the correctness of his/her response accompanied by physical manifestations of stress such as frowning, hand wringing, etc ;

3) Negative--verbal and non-verbal behaviors indicating frustration and distraction,

examples--"I don't know that," "This is hard," need for frequent breaks, removing earphones, etc.

Scoring took the form of simple tabulations of the number of occurrences for each behavior

CHAPTER III
RESULTS

Data were analysed using the Statistical Package for the Social Sciences (SPSS), Release 8.1 on an Amdahl 470 V/6-11 with OS/MVS Release 3.8 and JES 2/NVE Release 3. Computation was done using the facilities of the Northeast Regional Data Center of the State University System of Florida located on the University of Florida campus, Gainesville, Florida.

Auditory Attentional Effects

On Differences Between Groups

One question posed in this study concerned possible differences between the groups' ability to perform competently on auditory tasks where the subjects' auditory attentional response was stressed or facilitated. Thus the research hypotheses, I H_o = MdRE-ST_{om} = MdRE-ST_{nom} and II. H_o = MdRE-FC_{om} = MdRE-FC_{nom} were generated

Error score distribution about median. In order to answer Hypotheses I and II, median response error scores on each subtest were computed using the Median Test procedure

(Siegel, 1956). Two by two bivariate frequency tables were assembled. Rows represented the number of subjects in each group whose error scores were in the same position in relation to the median. Columns gave the number of members within each group whose error scores were either above or (at or) below the median. The data were analysed using Fisher's Exact Probability Test (Seigel, 1956) to determine whether high scores were related to particular group membership. In no case did the difference in the distribution of scores reach a statistically significant level ($\alpha = .05$). Table 1 represents those results.

Mean error scores. Table 2 presents means and standard deviations for each group by subtest. This central tendency statistic was not submitted to further analysis due to (a) its' unsuitability in representing data which is noncontinuous and skewed in distribution such as the percentage error scores recorded for this study and, (b) the obvious size of the standard deviations derived in relation to mean error scores, which would preclude the efficacy of a t-test procedure.

Skewed effects on median error scores. In order to ascertain whether or not the central tendency information on which these findings were based were affected by the presence of scores occurring in a remote region of the distribution, the Moses Test of Extreme Reaction (Siegel,

Table 1. Difference in distribution about the median error score.

Test	Median Error Score	Distribution	Group OM	Group NOM
CSRE	90	above	6	4
		at or below	6	8
CSREP	70	above	6	4
		at or below	6	8
CSLE	99	above	9	5
		at or below	3	7
CSLEP	99	above	8	5
		at or below	4	7
ASST	30	above	2	4
		at or below	10	8
ASSTP	35	above	7	5
		at or below	5	7
ASFC	65	above	6	6
		at or below	6	6
ASFCP	10	above	4	7
		at or below	8	5
SSWST	34	above	6	5
		at or below	6	7
SSWFC	34.5	above	7	5
		at or below	5	7
GFWST	48.5	above	6	6
		at or below	6	6
GFWSTP	25.5	above	5	7
		at or below	7	5
GFWFC	16.5	above	7	5
		at or below	5	7
GFWFCP	26	above	5	6
		at or below	7	6

*A= .05

Table 2. Mean error score, standard deviation by groups

Test	$\bar{x}_{om}$	s_{om}	$\bar{x}_{nom}$	s_{nom}
CSRE	70.000	37.899	74.188	29.374
CSREF	60 000	39.542	59.188	32.039
CSLE	90.833	23.143	87.500	17.122
CSLEF	85.833	26.784	83.333	23.868
ASST	71.666	30.698	75.833	26.443
ASSTF	41 666	29.797	45.833	35.021
ASFC	52 500	41.148	80.833	33.154
ASFCF	24.166	29.063	30.833	35.021
SSWST	37 500	19.017	34.666	15.300
SSWFC	44.251	21.740	35 333	16 578
GFWST	51.583	13 911	48 750	18.101
GFWSTF	27.888	23.993	40.166	29.783
GFWFC	23.250	20.521	23.250	26.385
GFWFCF	34.166	33.066	38 166	33 528

1956) was applied to the data. Results appear in Table 3.

A significant (α = .05) number of the NOM group's error scores were found at extreme points of the distribution range for three subtests. On the CSLE and CSLEF, many subjects (in both groups) were unable to give any correct responses at all, resulting in a clustering of scores at the highest limit of the error score range. Members of the NOM group obtained some of the highest and lowest error scores on the GFWST. The significance of this extreme distribution was lost, however, when a procedure to remove 5% of the scores from either end of the distribution range was implemented. This result indicates that the difference was attributable to a single observation.

Summary. No significant differences were found (α = .05) between the groups' error score distribution about the median error score for each group. Evidence of a skewed distribution was found on the CSLE and CSLEF subtests. Research hypotheses I and II cannot be rejected on the basis of these findings.

On Differences Between Subtests

Another way to look at the groups' performance is to assess whether or not differing test conditions (left ear/right ear presentation, stressed/facilitated attentional demand) significantly affected each group's error score.

Table 3. Presence of extreme scores within the error score range

Test	Span All Data	p =	Span 90% Data	p =
CSRE	20	.158	18	.500
CSREP	21	.295	21	.353
CSLE	18	.034*	14	.050*
CSLEP	19	.034*	14	.050*
ASST	22	.500	21	.353
ASSTP	21	.295	19	.680
ASFC	21	.295	18	.500
ASFCP	19	.077	17	.333
SSWST	24	1.000	19	.680
SSWFC	24	1.000	17	.333
GPWST	18	.034*	18	.500
GPWSTP	21	.295	16	.200
GPWFC	22	.500	21	.953
GPWFCP	22	.500	21	.953

*α = .05

Distribution about median difference score. Differences between the groups were investigated applying the nonparametric Median Test procedure and Fisher's Exact Probability Test (Siegel, 1956) to computed medians of the difference between subtests ASST-ASFC, ASSTF-ASFCF, CSLE-CSRE, CSLEF-CSREF, SSWST-SSWFC, GFWST-GFWFC, GFWSTF-GFWFCF. Table 4 presents those results. No significant differences (α = .05) in the distribution of scores around the median subtest difference score was found.

Ranked mean error scores by group. A Wilcoxon Matched Pairs Signed Ranks procedure, a nonparametric alternative to a t-test useful for analysis of data derived from small, related samples (Siegel, 1956), was applied to the data. This procedure employs both the direction and the magnitude of ranked mean differences between pairs in making decisions regarding significance. Results are shown in Table 5.

For both groups, significant differences (α = .05) were found in the ranked mean difference scores obtained on subtests of the Rapidly Alternating Sentences Test, Competing Sentences Test (paraphrased response criterion) and the Goldman-Fristoe-Woodcock Test of Auditory Discrimination (percentage error score). In addition, the OM group attained significantly different (α = .01) ranked scores on subtests of the Staggered Spondaic Word Test.

On the Rapidly Alternating Sentences Test, significant differences (α = .05) were apparent for both scoring

Table 4. Distribution about the median difference between subtests.

Test	Median Difference	Distribution	Group OM	Group NOM
ASST/ASFC	10	above	6	5
		at or below	6	7
ASSTP/ASFCP	10	above	6	5
		at or below	6	7
CSLE/CSRE	0	above	4	6
		at or below	8	6
CSLEP/CSREP	20	above	4	7
		at or below	8	5
SSWST/SSWFC	-1	above	4	7
		at or below	8	5
GFWST/GFWFC	2.5	above	7	5
		at or below	5	7
GFWSTP/GFWFCP	2-5	above	5	7
		at or below	7	5

* α = .05

Table 5. Difference between subtest mean ranked error scores.

Test	OM Group		NOM Group	
	Ties	z-score	Ties	z-score
ASST/ASFC	3	-2.192*	4	-2.240*
ASSTP/ASFCP	2	-2.293*	2	-2.803**
CSLE/CSRE	7	-1.753	3	-1.422
CSLEP/CSREP	4	-2.521**	2	-2.242*
SSWST/SSWFC	4	-2.521**	1	-.311
GFWST/GFWFC	1	-2.934**	0	-2.824**
GFWSTP/GFWFCP	0	-.392	0	-.628

* $\alpha = .05$

** $\alpha = .01$

criteria. Subjects in both groups obtained lower error scores on the ASFC where stimulus sentences were presented monaurally to the right ear than on the ASST where they received dichotic 300 millisecond sentence segments. These differences became greater between subtests when response requirements were less stringent. More subjects in each group (1 in OM, 3 in NOM) had larger error score differences when a pharaphrased response was accepted.

When the paraphrased response was accepted on the Competing Sentences Test, both groups contained more subjects making less errors on right ear-delivered stimuli than on left ear-delivered stimuli. Significance levels for this difference were not the same for both groups. For the OM group, excepting ties, all eight remaining subjects received higher error scores in the left ear than the right ear condition. However, of the 10 NOM subjects remaining after ties, two received higher error scores in the right ear than left ear conditions.

Significant differences (α = .01) were also recorded on the Goldman-Fristoe-Woodcock Test of Auditory Discrimination. Subjects in both groups were able to perform better in the quiet condition (GFWFC) than in the noise condition (GFWST). This difference was not found for GFSSTF/GFWFCP. The percentile rank, of course, bears an inverse relationship to the percentage error score, so the direction of ranked score differences would be expected to change. Moreover, the percentile rank calculation used in the GFW Test Manual's

Appendix C (p. 28) results in values representing the midpoint of each raw score interval, so that differences occurring at the upper or lower limits of those intervals would be smoothed.

For the OM group only, significant differences ($\alpha = .01$) in direction and magnitude of error score rankings were found between the stressed and facilitated attention subtests of the Staggered Spondaic Word Test. Eight members of this group obtained a higher error score on the SSWFC than on the SSWST while the rest of the group members showed no change in scores.

Summary. When considering the distribution of scores about the median error score for each subtest, or the distribution of difference scores about the median difference score between test conditions, no significant differences ($\alpha = .05$) are found between the OM and NOM groups. Therefore, research hypotheses I and II posed for the purposes of this study cannot be rejected. However, when magnitude as well as direction of difference between test conditions was considered, OM and NOM groups did not appear to be exactly the same. Significant levels ($\alpha \leq .05$) of ranked error score differences were attained by both groups when performance under stressed attentional conditions was compared to that under the facilitated conditions. The significance level was not always the same for both groups. In addition, the OM group performed differently on the SSW than did the NOM group, reversing direction of differences

from that for other tests by obtaining more and lower error scores on the stressed than on the facilitated subtest (α = .01).

Performance Analysis

Another question asked in this study inquired into the efficacy of error analysis and behavioral observation in differentating between the OM and NOM groups. It was felt that a comparative examination of error types and performance-related behaviors might reveal patterns which illustrated differences at a qualitative information level.

Error Types

Figure 1 presents the total error type percentage for each group. Figures 2 through 4 graphically display the percentage of error types committed by each group on each test, entered by test condition. Paraphrased response error patterns are not reflected in these graphs. Some responses were tabulated in more than one category. (For example, on the SSW where three of four syllables were repeated, with the second and third being reversed from the presentation order, that response would be classified as both an Order and a Recall error.) As can be seen, not every type of error was committed on each test. Responses required on some tests did not lend themselves to commission of certain errors (e.g. Laterality errors on the AS).

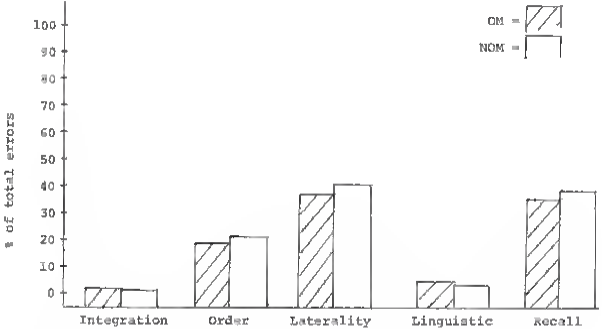


Figure 1 Total percentage of errors by type. (Decimal values rounded to nearest 1/100.)

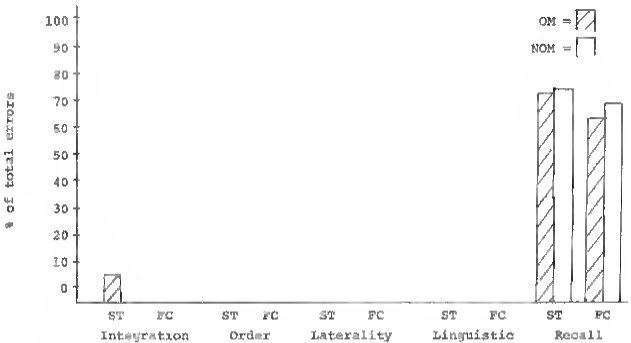


Figure 2. Percentage of error types on Rapidly Alternating Sentences Test. (Decimal values rounded to nearest 1/100, totals below 3% not displayed.)

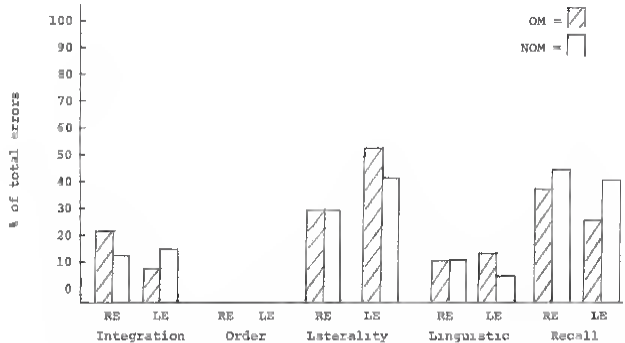


Figure 3. Percentage of error types on Competing Sentences Test. (Decimal values rounded to nearest 1/100, totals below 3% not displayed.)

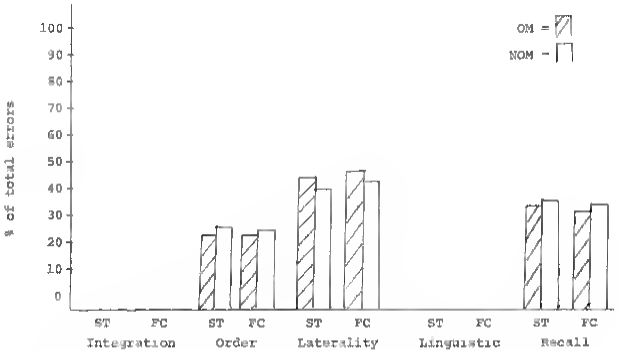


Figure 4. Percentage of error types on Staggered Spondaic Words Test. (Decimal values rounded to nearest 1/100, totals below 3% not displayed.)

Overall, differences between the OM and NOM groups appear to be negligible for each error type. Patterns were different between tests and subtests, however.

The highest percentage of error type occurred in the Laterality category (OM = 41%, NOM = 37%), followed by Recall (OM = 35%, NOM = 33%). The OM group demonstrated more Laterality errors than did the NOM group. Differences between the two groups in this error category were greatest on the CSLE test (OM = 53.5%, NOM = 41%). Errors in Laterality accounted for the same proportion of the total for both groups on the CSRE (30%). The direction of difference was the same for both conditions of the SSW (SSWST, OM = 43%, NOM = 39%; SSWFC, OM = 45%, NOM = 41%).

In the Recall error category, NOM's attained a CSLE error rate of 40% and a CSRE error rate of 44%, while the OM's had a CSLE error rate of 26% and a CSRE error rate of 30%. Recall errors accounted for most of the errors on the ASST for both groups (OM = 75%, NOM = 74%). These error rates were reduced on the ASFC where the OM's errors represented 63% of their total errors and the NOM's were at 68%. Percentage of Recall errors was also similar for the groups on the SSW (SSWST, OM = 33%, NOM = 35%, SSWFC, OM = 32%, NOM = 34%).

Analysis of errors on the Staggered Spondaic Words Test accounted for all but a negligible portion of the Order error category. For an error to be placed in this category, either a substitution for a syllable appeared in the presence

of two or three stimulus syllables, or a stimulus syllable appeared but repeated differently than the presentation order. On the SSWST, this type of error represented 23% of the errors committed by the OM group and 26% of the errors committed by the NOM group. Little change is evident on the SSWPC where the error rates are 23% for the OM's and 25% for the NOM's.

Integration errors occurred chiefly on the Competing Sentences Test. The percentage of errors was higher for OM group members when the target sentences were presented to the right ear (OM = 21%, NOM = 13%), but this pattern was reversed when the left ear received the stimulus to be discriminated (OM = 8%, NOM = 15%). On the Rapidly Alternating Sentences Test, one OM subject integrated part of a previous stimulus sentence into his repetition of other sentences during the stressed attention condition.

For the total Linguistic error type category, the OM's placed at the 3.5% level, the NOM's at the 3% level. In two subtests the OM's error rate was higher than the NOM's (CSLE, OM = 13%, NOM = 4%, ASPC, OM = 39%, NOM = 32%). On the ASST, NOM's errors were 26% of the total while the OM's were 20.5%. The groups' Linguistic error rate was the same on the CSRE.

Performance-related Behaviors

As shown in Table 6, the OM group displayed more of each of the stress-related behaviors defined for this study

Table 6. Observed occurrences of performance-related behaviors

Type	OM Total	OM $\bar{x}$	NOM Total	NOM $\bar{x}$	Percentage Difference
Latency	135	11.25	114	9.5	18
Confirmation	151	12.58	102	8.5	48
Negative	302	25.16	199	16.58	52

* α = .05

at rates which were comparatively higher than the behavioral occurrences of the NOM group, i.e. Latency 18%, Confirmation 48% and Negative 52%. Comparison between OM and NOM groups using the mean number of occurrences of each of these behavior types employing a Student's t-test (Mendenhall, 1971) revealed no significant differences ($\alpha = .05$).

Although differences in these stress-related behavioral events did not reach statistical significance, their pattern of occurrence can be instructive when viewed in conjunction with other information derived from the research data generated by this study. The actual difference in the number of each of these behavior types defined for each group by subtest is displayed in Table 7. It can be seen that the primary source for the difference between the groups in the amount of Confirmation behaviors observed occurred on two subtests, the SSWFC and GFWST. The OM group committed a total of 42 more confirmation-seeking behaviors under visible stress reactions than did members of the NOM group. In the Negative behavior category, on the other hand, the differences between the groups is consistent on seven of the eight subtests. The OM's emitted a greater number of negative responses in each instance except on the GFWST, where the difference between the groups is negligible.

Summary. Analysis of median difference of error scores did not reveal any significant differences between OM and NOM groups' distribution of scores when auditory attentional

Table 7. Difference between groups in total behavioral occurrences by subtest.***

Subtest	Latency	Confirmation	Negative	Total
CSRE	+ 2	+11	+16	+29
CSLE	+ 4	0	+10	+14
ASST	- 6	- 2	+ 5	- 2
ASFC	- 5	- 1	+12	+ 6
SSWST	+ 1	-17	+32	+16
SSWFC	+19	+21	+19	+59
GFWST	- 7	+21	- 1	+13
GFWFC	+13	+16	+10	+39

***Note. + = more OM behaviors
- = more NOM behaviors

skills were stressed or facilitated. Significant differences ($\alpha \leq .05$) were found for both groups between the mean ranked differences in test conditions.

Predictive Value

An additional research question proposed for exploration in this study was whether group membership could be predicted by error scores for the tests used in this study. To answer this question, a Stepwise Discriminant Analysis procedure using Mahalanobis distance (Cooley and Lohnes, 1971) was applied to the test error score data. Results of that procedure are shown in Table 8. Of the eight subtest error scores available, five were used to develop an equation capable of accurately predicting group membership for 75% of the sample (Table 9). The value of the predictive formula did not reach significance ($\alpha = .05$), although its predictive usefulness was high. When information derived from demographic variables were also made available (Tables 10 and 11), the predictive value did not increase although F-values were approaching significance. Predictive value based on demographic variables alone was lower than test scores alone as shown in Tables 12 and 13).

Relationship Among Subtests

Because the prediction accuracy of subtest error scores was higher than might be expected considering

Table 8. Stepwise test variable selection.

Step No.	Variable	F-value	D.F.	Significance
1	SSWFC	1.2883	1,22	.2686
2	ASFCP	2.0407	2,21	.1545
3	GFWSTP	1.7065	3,20	.1978
4	GPWFC	1.9601	4,19	.1418
5	GPWST	1.8442	5,18	.1548

* α = .05

Table 9. Classification results, test discriminant analysis.

Actual Group	No. of Cases	Predicted Group OM	NOM
OM	12	9 (75%)	3 (25%)
NOM	12	3 (25%)	9 (75%)

Table 10. Stepwise combined variable selection

Step No.	Variable	F-value	D.F.	Significance
1	Educ	1.8000	1,22	.1934
2	SSWFC	2.0614	2,21	.1523
3	ASFC	2.4704	3,20	.0915
4	SES	2.4131	4,19	.0842
5	GFWSTP	2.4394	5,18	.0743
6	GFWFC	2.2004	6,17	.0940

* α = .05

Table 11. Classification results, combined discriminant analysis

Actual Group	No. of Cases	Predicted Group OM	NOM
OM	12	9 (75%)	3 (25%)
NOM	12	3 (25%	9 (75%)

Table 12. Stepwise demographic variable selection.

Step No	Variable	F-value	D F	Significance
1	Educ.	1.8000	1,22	.1934
2	I.Q.	1.5002	2,21	.2460

* α = .05

Table 13. Classification results, demographic discriminant analysis.

Actual Group	No of Cases	Predicted Group OM	NOM
OM	12	8 (66.7%)	4 (33.3%)
NOM	12	4 (33.3%)	8 (66.7%)

previously delineated non-significant findings, a Pearson Product Moment Correlation (Mendenhall, 1971) procedure was performed using individual error score data. A significance level of $\alpha = .0002$ was used due to the large number of correlations analysed (253). Thirty coefficients of correlation (r) are indicated to be at or below the required significance level. A coefficient of determination, r^2 (Roscoe, 1969), was derived for each of those correlations. This statistic represents the proportion of the variance for one member of a correlated pair that can be attributed to the other. Such a measure of the strength of the relationship is desirable when comparing measurement instruments designed for equivalent or highly similar evaluations. Table 14 presents these significant correlations.

Between the two conditions of each test, strong correlations are evident for ASST/ASFC ($r^2 = .566$), ASSTF/ASFCF ($r^2 = .753$), SSWST/SSWFC ($r^2 = .763$). On the SSWST/SSWFC correlation, the location of each subjects' scores around the mean was the same with the exception of one score. For the ASST/ASFC relationship, the distribution of scores in relation to the mean changed for only four subjects out of 24, while this same change occurred for only three subjects in the ASSTF/ASFCF relationship. Correlations were also found between ASTF/ASFC and ASST/ASFCF.

Another type of strong correlational relationship occurred between the two different scoring versions for a single subtest for all the tests where two versions were

Table 14. Best correlations (α = .0002)

Rank	Variables	r	r^2
1	CSLE/CSLEP	+.9627	.926
2	CSRE/CSREP	+.9375	.878
3	SSWST/SSWFC	+.8737	.763
4	ASSTP/ASFCP	+.8716	.759
5	GFWST/GFWSTP	-.8582	.736
6	GFWFCP/ASST	-.8317	.691
7	ASST/CSRE	+.8247	.680
8	ASST/CSREP	+.8060	.649
9	GFWFCP/SGWFC	-.7907	.625
10	ASST/ASSTP	+.7701	.593
11	ASFC/ASFCP	+.7615	.579
12	GFWFCP/CSREP	-.7576	.573
13	ASFC/CSRE	+.7528	.566
14	ASST/ASFC	+.7528	.566
15	GFWFCP/CSRE	-.7484	.560
16	GFWFCP/ASFC	-.7229	.522
17	ASFCP/SSWST	+.6915	.478
18	ASSTP/SSWFC	+.6856	.470
19	ASSTP/CSREP	+.6719	.451
20	ASSTP/ASFC	+.6674	.445
21	ASST/ASFCP	+.6659	.443
22	ASFC/CSREP	+.6636	.440
23	ASSTP/SSWST	+.6520	.425
24	GFWFCP/SSWST	-.6489	.421
25	SCWST/Race	+.6483	.420
26	GFWFCP/SSWFC	-.6467	.418
27	SSWST/CSRE	+.6465	.418
28	ASSTP/Age	-.6421	.412
29	SSWFC/Race	+.6385	.408
30	GFWFCP/ASSTP	-.6309	.398

used. That is, CSLE/CSLEP (r^2 = .926), CSRE/CSREP (r^2 = .878), GFWST/GFWSTP (r^2 = .736), GFWFC/GFWFCP (r^2 = .625), ASST/ASSTP (r^2 = .593), ASFC/ASFCP (r^2 = .579). In the case of the Competing Sentences Test, only two subjects' position changed with regard to the within subtest mean for the two scoring versions on the CSRE and one subject's position changed between CSLE scoring versions. A negative relationship occurred between the percentage error and percentile placement scores for each of the Goldman-Fristoe-Woodcock Test of Auditory Discrimination subtests. On the GFWST, six out of 24 subjects failed to maintain a negative relationship where the error score and percentile score were inversely related to the mean. Interestingly, five of these six subjects were in the OM group. Only four subjects did not maintain this inverse relationship between scoring versions of the GFWFC. In this case, three of the four subjects were classified in the NOM group. The strength of correlations on the GFW is to be expected since the percentile placement score is based on the subject's error score as well as chronological age. Four subjects' verbatim response error scores were higher than the subtest mean while their paraphrased response score was lower than the mean on the ASST subtest. For the ASFC, again four subjects' scores changed direction from the mean between scoring procedures.

Over half of the remaining significant correlations demonstrate a relationship between a subtest of the Rapidly Alternating Sentences Test and subtests of other tests.

Negative relationships between the error scores on ASST, ASSTP and ASFC and the percentile placement score GFWFCP are strong, respectively r^2 = .691, r^2 = .398, r^2 = .522. Strong positive relationships exist between ASST and CSRE (r^2 = .680), CSREP (r^2 = .649), ASFC and CSRE (r^2 = .566), CSREP (r^2 = .440) and ASSTP and CSREP (r^2 = .451). Paraphrased response scoring versions of the AS were related to both subtests of the SSW (ASFCP/SSWST, r^2 = .478, ASSTP/SSWFC r^2 = .470). Finally, the paraphrased error score ASSTP was indicated to be negatively related (r^2 = .412) to subjects' chronological age.

Of the remaining six significant correlations, five involve the SSW, three pairings between SSW subtests and other test variables and two pairings with demographic variables. Error scores for both subtests of the SSW are indicated as being related to race (SSWST/Race, r^2 = .420, SSWFC/Race, r^2 = .407). For the four Negro subjects included in this study, error score rankings on the subtests were high: SSWST 1, 2, 4 and 9th highest error scores, SSWFC 1, 2, 4, and 8th highest error scores. Both subtests of the SSW are also negatively correlated with the GFWFCP. As would be expected considering these correlations, both the SSWST and GFWFCP are correlated with the CSRE.

In summary, within test scores (between subtests, between scoring procedures) are highly correlated. Additionally, many significant (α = .0002) correlations were found between the AS, CS and SSW tests. Most of the subtests

showed a significant negative correlation with the subtest GFWFCP. However, except for correlations between scoring versions, neither the C&LE nor GFWST were significantly correlated with other variables defined in this study. Age and race variables were found to be significantly correlated with error scores on three subtests. No significant correlations between demographic variables were found.

CHAPTER IV
DISCUSSION

Interpretation of Results

Effects of Recurrent Otitis Media

When comparing the OM and NOM groups on each subtest, their performances appear to be remarkably similar. Central tendency measurement, whether based on mean, median or median difference error scores indicates that the distances between the OM and NOM groups' error scores are not large enough to be statistically significant.

The OM and NOM groups' error scores were consistently larger on all tests used in this study than were those found in normal and learning disabled populations (Tables 15, 16, 17, 18). This occurred even though their communicative handicaps were at least partially negated by use of lenient scoring procedures (paraphrased responses). A large portion of the subjects' errors were accounted for by laterality factors, with more errors occurring on stimuli presented to the left ear than to the right ear for both groups. The right ear advantage (REA) is apparent for most young children, and is commonly discussed in the literature dealing with auditory perceptual testing (Duane, 1977; Willeford, 1978).

Inspection of individual error scores on the subtests (Appendix C) reveals that for some pairs, quite large performance differences are evident (e.g. Subjects 5/6, 13/14). In fact for nine out of 12 OM/NOM pairs, consistent differences in error scores can be found. However, these differences are not in the same direction for every pair resulting in the balance indicated by the central tendency statistic for each subtest.

It is also noteworthy that on some of the subtests, most of the subjects in both groups obtained error scores at or near 100%, thus rendering difficult the task of discriminating between the group members' ability to perform task requirements. This was particularly true on tests where subjects were required to repeat a lengthy verbal string (i.e. Competing Sentences and Rapidly Alternating Sentences Tests). Table 15 shows the Competing Sentences Test mean and range of error scores for OM and NOM subjects of this study compared to those of children with normal central auditory function as presented by Willeford (1978) Table 16 gives mean and range of error scores on the Rapidly Alternating Sentences Test for the OM and NOM groups compared to norms obtained by Willeford (1977). The error scores of the communicatively handicapped children used in this study are much higher for both tests than those of the normative population. A similar trend toward improvement with age is seen for all three groups. However,

Table 15. Competing Sentences Test error scores comparing OM and NOM groups' performance to established norms (Willeford, 1978) by age.*

Age	Group	N	Mean Error Score (%) LE	RE	Range (%)
4	OM	5	100	82	40-100
	NOM	4	92.5	80	70-100
	Norm	**	**		**
5	OM	2	90	50	0-100
	NOM	4	90	52.5	20-100
	Norm	12	70	06	0-100
6	OM	4	70	52.5	10-100
	NOM	2	60	65	20-100
	Norm	19	45	08	0-100
7	OM	1	0	70	0- 70
	NOM	2	75	25	0- 90
	Norm	18	29	08	0-100

* OM and NOM scores used for comparison are those for the paraphrased response scoring version (CSREP, CSLEP) in order to be consistent with conventional test response requirements.

** normative data not available for this age group.

Table 16. Rapidly Alternating Sentences Test error scores comparing OM and NOM groups' performance to established norms (Willeford, 1977) by age.*

Age	Group	N (Ears)	Mean Error Score (%)	Range (%)
4	OM	5	58	40- 90
	NOM	4	62.5	30-100
	Norm	**	**	**
5	OM	2	55	20- 90
	NOM	4	55	10-100
	Norm	20	01	90-100
6	OM	4	22.5	0- 50
	NOM	2	25	20- 30
	Norm	20	01	0- 10
7	OM	1	10	10
	NOM	2	15	10- 20
	Norm	20	01	0- 10

* OM and NOM scores used for comparison are the paraphrased response scoring version of the stressed subtest (ASSTP) in order to be consistent with conventional test procedure and response requirements.

** normative data not available for this age group.

even at age seven years, differences between this study's subjects and the children used in the normative sample are evident. The variable of age was significantly correlated only with the ASSTF in this study. On the ASST, most of the errors for both groups were classified as Recall errors which, using the lenient paraphrased response requirement, meant either a total lack of response or a fragmentary and/or inappropriate answer. Interference from the nontarget ear was clearly demonstrated in the form of Laterality and Integration error types which were the most frequent error responses on the CS for both groups.

As another interesting comparison, in Table 17 the OM and NOM groups' error scores are compared to those of a group of 14 learning disabled (L.D.) children aged six to 16 years with normal auditory acuity and intelligence (Pinheiro, 1977) and a group of children aged six to 10 years with a history of persistent middle ear infections (PME) studied by Manchester (1980). The differences between error scores for this study's sample and those of Pinheiro and Manchester may result from status of communicative function (neither the P.M.E. or L.D. group was identified as deficient in verbal expressive skills) and from the older ages of subjects in the groups.

Differences between the research groups were more apparent but still nonsignificant on the Staggered Spondaic Word Test. One-half the NOM group did not show an improvement in their error score when provided with a warning cue

Table 17. Error score means and standard deviations on the Competing Sentences and Rapidly Alternating Sentences Tests for OM, NOM, Learning Disabled (LD)* and Persistent Middle Ear Infection (PME)** samples.***

Test	Group	Error Score $\bar{x}$	s
Alternating Sent.	OM	41.70	29.80
	NOM	45.80	35.00
	L.D.	4.80	6.65
Competing Sent.--RE	OM	60.00	39.50
	NOM	59.10	32.00
	L.D.	5.50	7.20
	P.M.E.	20.80	18.90
Competing Sent.--LE	OM	85.80	26.80
	NOM	83.30	23.90
	L.D.	28.80	20.40
	P.M.E.	63.80	27.20

* Pinheiro (1977), L.D. subjects aged 6-16 years.

** Manchester (1980), P.M.E. subjects aged 6-10 years.

*** OM and NOM scores used for comparison are those for the paraphrased response scoring version (AESTP, CSREP, CSLEP) in order to be consistent with conventional test response requirements.

before stimulus onset. However, all members of the OM group actually had the same or larger error scores in the cued (facilitated attention) condition. It was observed that these subjects were prone to repeat the cue, "Are you ready," before attempting to repeat the two spondee words. This response was discouraged during the practice trials, however, for many children this feedback seemed to exacerbate the problem. Subjects often either continued to repeat the cue or began to repeat it, then hesitated before attempting to repeat the spondee stimuli. This behavior indicates a difficulty in selectively attending to target stimuli and was more prevalent in the OM than the NOM group.

Normative data are not available for the SSW on children in the age groups used in this study. Katz (1978) states that variability in scores increases for children below 11 years of age. Range and standard deviation of scores for subjects in this study were large. Katz states that, in general, a laterality effect favoring the right ear is observed in young children. This was true for both OM and NOM groups in this study. Subjects emitted more error responses to both competing and noncompeting syllables presented to the left ear than to the right. Both OM's and NOM's experienced more difficulty with the competing syllables than with the noncompeting syllables, documenting the increased difficulty of the divided attention task.

Both groups were deficient on their performance on the Goldman-Fristoe-Woodcock Test of Auditory Discrimination.

Although some observable differences occurred between subject pairs (e.g. Subjects 3/4, 21/22), in general the groups' scores were highly similar. Table 18 presents the OM and NOM percentile placement scores for the GFW compared to those of 53 children diagnosed as having either an auditory or visual learning disability (Sweitzer, 1977). It can be seen that again, the OM group obtained lower percentile placement scores than any of the other groups sampled. Even though the L.D. population was older ($\bar{x}$ = 8.2 years), the NOM's did perform better in the noise condition than either the L.D. auditorily handicapped children or the OM group.

Summary. Both groups' poor performance on these auditory processing tests point to a clinically significant auditory deficiency. However, differences between the groups were not statistically significant. This result is interesting when compared to the existing literature comparing OM type children to groups of normally functioning peers where significant differences are consistently reported. Two recent studies, for example, employed many of the same qualifying stipulations and test instruments and reported significant differences when comparing OM and normal otic history groups (Kessler, 1978, Manchester, 1980).

Effects of Attentional Demand

Results of the correlational analysis, when viewed with regard to mean error scores across groups indicate that the

Table 18. Mean percentile scores on Goldman-Fristoe-Woodcock Test of Auditory Discrimination for OM, NOM and Learning Disabled (L.D.) samples *

Group	N	Subtests	
		Quiet (GFWFCP)	Noise (GFWSTP)
OM	12	34.16	27.66
NOM	12	38.16	40.16
L.D. - auditory	27	45.74	32.18
L.D. - visual	16	62.63	63.75

* Sweitzer (1977), L.D. subjects mean age at 8;2 years.

modifications in test procedures used for this study did produce conditions in which attention was either stressed or facilitated.

Maintenance of the internal validity of the tests employed in this study is evidenced by the strong correlations between subtests for the Rapidly Alternating Sentences Test and the Staggered Spondaic Words Test. Such strong correlations were not found on the Competing Sentences Test or the Goldman-Fristoe-Woodcock Test of Auditory Discrimination, neither of which were altered for use in this study. For both tests, correlations approaching significant levels were noted, however (i.e. CSLEF/CSREF, $r = .5840$, $r^2 = .341$; GFWST/GFWFC, $r = .6165$, $r^2 = .380$).

The fact that scores for the groups were different between these highly correlated subtests is indicated by the significant differences obtained in the mean rankings of scores between test conditions for each group. On the AS and GFW tests, the stressed attention task was harder for subjects in both groups than the facilitated attention task. On the CS, the left ear presentation condition elicited more subject errors than the right ear presentation condition. Only on the SSW and only for the OM group was the direction of difficulty unexpected in terms of assumed attentional demand. It could be that, in view of the subject response confusion in dealing with the cue on the SSWFC (as discussed previously), attentional demand on that subtest was not facilitated but rather was simply different

and more complex than the SSWST. That is, while the SSWST was a divided attention task, introduction of the cueing phrase added a selective component to the response demand. The stimuli had to be attended to while the cue was ignored in order for the defined correct response to occur. The effect of this additional component appeared in the scores of members of both groups, but resulted in significantly larger differences between subtests only for subjects in the OM group. On the CS, subjects were simply unable to ignore the nontarget competing sentence stimulus. In some cases, selective attention to the target stimulus was difficult in both ears, but more often and to a greater degree, subjects were unsuccessful in ignoring the right ear stimulus when instructed to attend to the left ear sentences.

Correlations between the verbatim and paraphrase scoring versions on the CS and AS tests indicate that scores were not a result primarily of the subjects' varying expressive language deficits. Although the demand for specific language performance was a factor in the error scores, indicated by the difference in median scores for three of the four tests between verbatim and paraphrased scoring versions, the distribution of the subjects' scores about those medians did not change. There were few subjects whose ability to perform the required task improved dramatically in relation to the performance of his group as a

function of reduced verbal response demands. The benefit of reduced linguistic response requirements was most noticeable on the ASFCP

Apparently all four tests were measuring the same kind of skills. There were strong correlations between the various subtests of these tests even though procedures for administration, stimulus type and mode of response were different for each test. The common elements in all these tests were, (1) use of speech stimuli, (2) presented auditorily through earphones, (3) requiring an active response regarding identification of the stimuli by the subject. The tests all measured children's ability to recognise and identify auditory linguistic structures. In each case, subjects' ability to respond correctly was affected negatively by decreasing the target signal's prominence, thus increasing the attentional demand for the subject.

The difference in the information provided by the subtests can be delineated using the parameters described by Garner (1974) which were discussed in Chapter II. The GFWFC and ASFC are considered to be single information source tasks which can be used as base measures of the subject's ability to respond. The ASFC offers more linguistic information upon which to make a response decision, but requires a verbal response. The GFWFC demands that the listener rely more heavily on acoustic cues while demanding a visual-motor and visual discrimination task as well. The lowest

scores across groups were on these single information source tasks. Groups appeared to be within normal limits on the ASFCP which indicates an adequate verbal response capability when attentional demand is unexacting. Depressed scores on the GFWFC indicate either that subjects experienced problems in discriminating the acoustic signal or had difficulty with the cross-modal response demand.

Subjects in this study appeared to be better able to attend to two different sources of information simultaneously (i.e. SSW) or related sources consecutively (ASST) than they were able to selectively ignore an information source The CS and GFWST subtests, selective attention tasks, proved to be the most difficult for all subjects, manifested in the highest error scores for any of the subtests. Subjects emitted the greatest number of stress-related behaviors, classified as Negative and Confirmation-seeking behavior types, during these subtests with the OM's demonstrating a higher behavioral rate than the NOM's. The majority of error reponses on the CS subtests illustrated interference from the nontarget signal.

Usefulness of Auditory Attentional Measures

Although no single measure employed in this study was capable of providing a means of discriminating between the OM and NOM groups, the cumulative information available from all four tests of auditory attention for speech was

used to correctly predict three-quarters of each group's membership. The probability that such a result would be obtained by chance was approximately 15%.

In generating a prediction formula, the subtest providing the most information in differentiating between group members was the SSWFC. Differences between group members' error scores in terms of both direction and magnitude of error score change from the SSWST were the most obvious. This was a divided attention task, with a selective component added, in which OM subjects performed more poorly than NOM subjects. The ASFCP was the easiest task for most of the subjects used in this study and was the second component in the prediction formula. It was strongly correlated with most of the other subtests not used in the formula (i.e the rest of the subtests requiring a verbal response). It provided information concerning tasks on which the NOM subjects generally performed less competently than the OM subjects. Finally, scores on the task which was most difficult for all subjects, the GFWST, added some information which when combined with the GFWFC scores, depicted some specific scoring consistencies between subject pairs. Although higher error scores were obtained by many subjects on the CSLE, the ceiling effect created on this subtest obviated its' usefulness as a discriminatory measure. Use of the demographic variable for which the groups were not matched, Education, and inclusion of SES information improved the statistical power (α = .09) but not the predictive

usefulness of the formula. More members of the OM group were enrolled in school and had a slightly higher mean SES than did the NOM's. It could be that these factors provided more practice for the OM subjects in listening/verbal response tasks employed in this study. Practice effects on performance of verbal recall and repetition tasks have been reported in the literature (LaBerg, 1972; Lachman, Lachman and Butterfield, 1973).

Conclusions

This study failed to find significant differences between children with or without a history of recurrent otitis media on tests of auditory function where attention to target stimuli was a defining factor. Two conclusions are possible based on these results. Either,

(1) subjects in both groups were alike in the characteristics important to this study's outcome, or,

(2) differences between subjects in the OM and NOM groups were not measured by procedures employed in this study.

No Differences Between OM and NOM Groups

There are several possible reasons why no significant differences between research sample subjects might exist.

Some are attributable to limitations inherent in the study methodology. Others would result from the nature of the problem under consideration.

Group classification. It is possible that the basis for assignment of subjects into the OM or NOM group was not sufficiently discriminating in terms of otic history. Group classification was made on the basis of the weighted score obtained on questions eight through 25 on the Parental Questionnaire (Appendix A). A cut-off score of 10 or less on even-numbered questions (otic history before age three years) was used as a criterion for placement in the NOM group. A larger score resulted in placement in the OM group. This choice was arbitrary but made in consideration of scores obtained by subjects with recurrent middle ear disease histories used in the study in which these questions were developed. Group placement in that study was done on the basis of a discriminant analysis of scores for answers to various combinations of those questions. It may be that a simple cut-off score was not sufficiently discriminating. Some evidence of otic and/or respiratory problems was given for 23 out of 24 of the subjects in this study. Although NOM group members had comparatively minimal pathological histories before age three, most of them had some otic problems after age three. Perhaps the effects of multiple middle ear or upper respiratory problems extend

beyond the speculated three year period. If so, then the dependent variable used in this study--recurrent otitis media--was the same for both groups.

However, in terms of the defining criterion, otic history before age three, these groups did appear to be different in their weighted scores. The questions used were validated (Kessler, 1978) as being an excellent tool for identification of middle ear problems. Parents reported no problems in understanding the questions or in answering them. The scores were easily derived. Avoidance of misclassification of these kinds of subjects might be possible by obtaining additional information specific to otic history to supplement the score obtained from these questions. Medical confirmation of diagnosis and treatment of an otitis media condition is certainly desirable, but seemingly difficult to obtain. Information from the physician or parent concerning number of occurrences of infection, duration and severity of episodes would provide additional, quantifiable data. Age of onset could be a differentiating factor. In short, the more detailed a description of the middle ear dysfunction that is available, the more precise classification would become, alleviating doubts regarding group homogeneity.

Source of attentional dysfunction. Another possibility in the observed similarity of auditory dysfunction for both groups is that the source of that dysfunction was not related to otic history but rather to some other variable

which the members of both groups had in common. Studies have been published giving evidence of some form of attentional deficit in populations with a variety of deficit-oriented classifications (Pinheiro, 1977; Costello, 1977; Zambelli et al., 1977). It may be that children variously labeled as minimally brain damaged, learning disabled, hyperactive, etc. share a common neurophysiological dysfunction with children having a history of recurrent otitis media and that this dysfunction results in the observed attentional deficits. Conversely, it is possible that a diversity of neurological anomalies could be manifested in very similar forms of auditory attentional deficits. As pointed out by Chelfant and Scheffelin,

> it is difficult to identify the cause of auditory processing disorders because different etiological factors are often characterized by many of the same behavioral symptoms. (1969, p. 17)

Another explanation, suggested by Dempsey (1977) is that the otitis prone condition is the result of genetic configuration which also causes auditory processing disorders.

Factors other than otic history may be primary in determining the appearance of attentional deficits as the form of a child's auditory dysfunction. For example, children with language/learning problems in which failure to recognize and employ linguistic units to segment incoming speech streams has resulted in recall deficiencies may appear to be failing in the attentional task when, in fact, failure

is an inability to translate an echoic image into short term memory store (Neisser, 1967). A communicatively handicapped child's interaction with his environment might be unrewarding enough to significantly decrease his speech-attending behavior. Lack of reinforcement or negative feedback concerning inappropriate verbal responses could lead to debilitating stress responses in demanding communication situations.

Summary It is not possible to say that the OM and NOM groups used in this study were significantly different in their auditory attentional task performance based on the findings of this study. Although one conclusion that might be drawn is that subjects in this study were similar in their auditory attentional abilities, some evidence was obtained which seemed to deny this conclusion. Differences in the quantity of stress-related behaviors combined with differing patterns of performance between stressed and facilitated subtests point toward group differences, although not at statistically significant levels. Derivation of a prediction equation with a 75% accuracy rate using only subtest error scores for identification of group classification is reasonably impressive for samples as closely matched on a number of variables as were the ones used in this study.

Existing Differences Not Measured in This Study

It could be that variables on which the OM and NOM subjects differed were not measured in this study. Again factors which might influence such an outcome can be found both in study design and in aspects of the problem area itself.

Sample size. The range of scores on each of the subtests used in this study is quite wide. This reflects the variety of performance abilities displayed by the children who were research subjects. Relationships between subjects, as discussed previously, tended to balance out scores perhaps obscuring some trends in scoring patterns. While there is the danger that a small sample might produce significant results based on the actions of one or two atypical subjects, it is also possible that differences which do exist are subtle and will only appear in the presence of a sample sufficiently large to testify to the representativeness of the data. That is, the greater the variance of the population, the larger the proportion of the population that ought to be sampled (Drew, 1976). When attempting to exercise control over a number of variables and working with samples drawn from unique populations, obtaining large numbers of individuals can be herculean task. However, it is possible that, using the resources of a number of public school services, private and

community speech and hearing clinics, a larger sample of the type used in this study could be obtained.

Dynamic processing event. Whenever some aspect of auditory processing is the subject of examination, it is important to understand that the investigation is simply a tap into an ongoing stream of perceptual activity. Information moves from sensory organs to cortex and back again in a feedback loop which modifies the actions of the perceiving individual (Luria, 1973; Haber, 1974). The attempt to assess discrete operations within a perceptual system is made by employing measurement techniques and response tasks designed to converge upon some point in time during that activity when the targeted operation is predominant. Behaviors which are defined as and assumed to represent the perceptual operation are observed and quantified. The validity of our evaluations is constantly open to question due to the nebulous state of the theoretical base for auditory processing functions. It may be that the methods used in this study were unsuccessful in isolating the attentional component of subjects' auditory behavior. Certainly other kinds of operations, other skills, were involved in performance of the tasks used in this study. For example, the GFW requires that each subject be able to discriminate between minimal phoneme pairs, make a cross-modal association to a line drawing (sometimes newly learned in the training procedure) and give the appropriate

visual-motor response of pointing. All the tests demand at least short term memory and recall abilities. The AS, CS and SSW require that subjects possess verbal imitative skills. It is possible that similar deficits in these areas on the part of these communicatively handicapped children obscured any attentional differences which existed, particularly on tasks such as the CSLE where very few subjects were even minimally able to perform competently.

Existence of other differences. Another possibility to be considered is that while the populations sampled do differ, the differences exist in some area other than auditory attentional behavior. It is obvious from the results of this study that both groups of children are severely disabled in their ability to manage auditory-verbal tasks. The overwhelming nature of their deficiency in handling auditory stimuli may mask more discrete, less observable or well-defined functions which are attributable to their different otio histories. Perhaps OM children experience specific deficits in integrating binaural stimulation depending upon the unilateral or bilateral form of the inconsistent hearing loss they suffered. It is possible that auditory attention is deficient in this population, but only for particular kinds of auditory events (e.g. competing speech situations versus environmental noise backgrounds). Time related factors may be related to this groups' deficiency to a greater extent than for other

disordered populations. The area to covered in a search for symptomology which describes this population and which might serve as a heuristic in the search for a neurophysiological source has certainly not been exhausted.

Summary. Another conclusion that can be stated based on the research findings is that this study was unsuccessful in measuring significant differences between the OM and NOM groups' auditory attentional behaviors. It is reasonable to reiterate, however, that some evidence was found which would imply a means of differentiating between such groups and would encourage further work in this area.

Implications for Future Research

Based on the knowledge gained in the course of this study and the findings resulting from it, suggestions can be made regarding both the design of studies investigating the influence of otitis media on communicative function and the research areas which might prove most fruitful.

Design Considerations

As in most research experiences, both strengths and weaknesses in this study's design became apparent as work progressed. Description of these factors should prove helpful in designing similar activity in the future.

Control of variables. As Ventry (1980) points out, control of internal validity is a primary concern in good research design. A major effort in this study was to identify and control as many of the demographic variables which might influence performance outcomes as was possible. This effort was largely successful and may, therefore, provide encouragement for replication in future studies. Factors such as age, sex, SES, I.Q., medical history and race were closely matched either by subject pair or by group. This matching was possible based on information gleaned from existing clinical files and responses on the Parental Questionnaire. Access to such information is attained by obtaining the cooperation of relevant agencies and use of a detailed written interview.

It was apparent from the results of the discriminant analysis of independent variables identified for this study that educational level was a factor in analysing group membership. This study's subject pool was exhausted before precise matching on this variable could be achieved. It is suggested that efforts to include a greater number of clinical resources from which to draw would solve this problem in the future. A breakdown of therapy history and communicative disorder type were not used in this study. Such detailed information might prove helpful in controlling variables which might influence individual performance and aid in differentiating between experimental groups. Again, this would require a

multi-source subject pool. Control of these variables provides greater confidence in statements attributing experimental outcomes to between-group differences.

Use of deviant control groups. In all but one (Zinkus et al., 1978), of the studies cited in the Review of the Literature, a group of children with some identified dysfunction (L.D., OM, M.R., D.) was compared to a group of children identified as functioning normally in the area of interest. Research on the effects of otitis media on speech/language development has consistently shown differences in abilities and function between OM children and normal controls. It seemed that the next logical question was whether these differences were attributable specifically to the otic disease or if they were actually common manifestations of all communicatively handicapped children. If there are differences specific to the OM population, qualification of those differences would be instructive in developing diagnostic and therapeutic taxonomies as well as allowing inferential pursuits of etiologies. Therefore, this study compared an OM group to a group which also demonstrated communication deficiencies of a similar nature. It may be that by attempting to so closely control demographic variables such as I.Q. and medical history, control subjects who were truly different from the experimental group were disqualified from participation. Nevertheless, it would be

difficult to state conclusions concerning the unique communication problems of the OM population unless those differences were evident in comparison to other speech/language disordered populations. Conversely, if auditory processing problems for both groups are exhibited in similar symptomology, investigation of those problems in a group whose physiological dysfunctions can be defined and quantified, such as the OM population, could be informative in the search for physiological dysfunction in those other auditorily dysfunctional populations. Such populations might include children with various configurations of hearing impairment, mentally retarded children, children with motor speech disorders and the like.

Identification of recurrent otitis media. The Parental Questionnaire used in this study was a valuable tool in obtaining information for subject classification. However, in order to separate OM subjects from other language deviant groups and provide more specificity for making difference judgments, further information would undoubtedly be helpful. Details concerning the history of otitis media occurrences would provide for more confident classification into OM groups. Age of onset of the first otitis media episode, the specific number and duration of the episodes, the severity of any concomitant hearing loss, the course of medical treatment are all factors which might discriminate between children who have experienced otic disease problems. This

kind of effort would necessitate contact and cooperation with the physician(s) actually involved in treatment of the disease. Problems in obtaining such information due to the transient nature of today's society might be overcome by using hospital well-baby clinics or other pediatric facilities as subject resource pools.

Description of methodology. A frequent criticism of the otitis media literature is that the methodology used in research studies is inconsistent and sometimes surprisingly incomplete (Rapin, 1979). Ventry (1980) reviews research in which little, if any, assessment of subjects' auditory acuity was reported. Instrumentation, data analysis, test procedures were often found to be sparsely described or unmentioned in published material. This study proposed to respond to most of Ventry's criticisms directly when choosing a methodology. Pure tone air conduction thresholds and tympanometric assessment of each subject in this study was accomplished in an endeavor to ensure that any observed differences between groups were not the result of discrepancies in the groups' hearing status. Examiners who were "blind" regarding the group classification of the subject were used in order to avoid contamination of response judgments by experimenter expectancies. Finally, when decisions regarding data treatment were made, procedures were chosen which were felt to be appropriate for use with small, atypical samples and data which was not expected to be normally distributed. These analytic techniques have been

described and referenced in order to provide an adequate base for critical examination.

Young children as subjects. Few published studies in the area of otitis media have employed children less than six years of age (cf Holm and Kunze, 1969; Needleman, 1977 for exceptions). This is partially attributable to the lack of standardized assessment tools which are appropriate or have normative data for very young children. Indeed, only one of the four tests used in this study (GFW) was structured in this way. This renders judgments concerning true deviation and severity difficult, especially with children where variability is so great within a normal population. However, the population of less than six years of age is that which is identified as experiencing the largest incidence of otitis media episodes (Northern and Downe, 1974). In addition, there is some evidence indicating that differences between these children and their peers tends to diminish with age (Rapin, 1979). It seemed to be important, therefore, that the speech and language behaviors of this younger population be documented. In this study, very little difficulty was encountered in persuading subjects to participate in and complete the research tasks. Basic clinical techniques using token reinforcement and behavioral management were employed to encourage each child's cooperative behavior while not prejudicing responses to test items. Careful explanation of procedures and verbally-expressed

positive attitudes were successful in dissipating resistance from the subjects. Use of existing clinical technology can facilitate work with young children. Such activity in the future would allow gathering of behavioral information to provide normative and comparative data bases.

Directions for Further Investigation

Research concerning the effects of recurrent otitis media is in its' incipiency. This study was proposed as a seminal activity. It addressed some problems which exist in the current literature and postponed approaching others. Continuing work in this area should yield information which can be used nomothetically not only as it applies to the OM population specifically, but also to the larger population of children with auditory processing dysfunction.

Establishing a data base. It is difficult to quantify the importance of language/learning problems in the OM population while lacking adequate reference information. For example, search of the literature yielded minimal information regarding the proportion of OM children in clinical populations such as public school speech and language disorders caseloads. Freeman and Parkins (1979) found a higher prevalence of middle ear disease in a sample of learning disabled children aged six to 14 years than in a normal control group. Kessler (1978) stated that children with a history of persistent middle ear infections

who could be classified as belonging to low SES classifications comprised a disproportionate segment of special education classes. Incidence figures on the distribution of the OM population in such clinical programs would testify to the importance of proposed research activity.

Estimates concerning the severity of an individual's dysfunction in auditory processing skills can only be made in comparison to normal and developmental function. Information in this area, particularly in the two to six year old interval is meager. Experimental samples of young children classified on the demographic variables delineated previously are recommended.

Refining methodology. As discussed previously, specification of processing deficits is difficult due in large part to the abstruse nature of auditory perceptual function. Techniques that will further qualify perceptual operations should be incorporated into the research methodology employed in studying auditory function in children. Cognitive psychologists and psychophysiologists, for example, are publishing their work using shadowing techniques and auditory evoked brain potentials which appear to provide a way of identifying and quantifying subjects' attentional responses (Sabat, 1978, Picton et al., 1978).

Existing assessment tools should be submitted to exacting task analysis in order to determine the various perceptual

and cognitive operations required by response demands. Experimental manipulation of the data and resource factors involved in these measures could be helpful in determining the limitations imposed by these factors on the auditory processor (Norman and Bobrow, 1974; Berlin and McNeil, 1976). Such activities would contribute to evaluation of the validity of current measurement instruments.

With few exceptions, reliability of the tests currently in use with this population has not been investigated. Replication of published work and multiple baseline measures are suggested to determine the representativeness of data which is obtained concerning the performance of both normal and auditorily dysfunctional children on these tasks.

Developmental dysfunctions could best be assessed by institution of longitudinal studies of the OM population. Menyuk (1975) recommends, for example, both small, controlled studies of children considered to be at risk for recurrent episodes of otitis media and children identified as having experienced this history in infancy. She suggests that such long-term investigations would provide information concerning a wide variety of speech and language abilities including onset of deviation from the developmental norm and the structural parameters of the deviations. She further proposes that post hoc analyses of measures used in such studies would aid in identification of efficient assessment tools.

Investigation of communicative/cognitive function. Evaluation of the OM child's auditory attentional behaviors

was an outgrowth from more general investigative activity concerning the speech, language and learning deficits observed in this population, and specific infrahuman research suggesting the possibility of neurophysiological anomalies resulting from early intermittant conductive hearing losses. Although significant differences between the groups used in this study were not found, serious auditory attentional deficits were clearly documented in the OM children. A connection between these attentional deficits and the speech and language disorders which many OM children exhibit is suggested based on a theory of selective attention propounded by Moray and Fittar (1973). They described the process of selective listening as a stochastic operation on the external sound environment with comparison to an internal model based on expectancies derived from past experience and directed by perceived task demands. The listener, then, develops strategies for processing ongoing acoustic stimuli such as speech based on his sensitivity to both the external and internal auditory environment and his past experience with such stimuli.

Snyder and McLean (1976) suggested a conceptual framework which could be employed for assessing the ability to formulate and apply processing strategies in language disordered children. They describe the development of language acquisition strategies in terms of information gathering and information processing activities which include the use of selective listening skills even at the

preverbal level. Menyuk (1979) describes the manner in which episodes of recurrent otitis media would disrupt a child's ability to devise language processing strategies, resulting in delays in speech and language development. For example, intermittent hearing loss would restrict the experiential data base upon which an internal model of a phonological system could be constructed. Thus, sampling of the acoustic stream would be inefficient due to lack of internal direction. Further categorization based on knowledge of morphophonemic and semantactic linguistic structures could be delayed by virtue of this inefficiency. Ultimately, Menyuk speculates, ineffectual strategy usage could result in an inability to form associations necessary for learning to read. She cites studies which reveal the existence of linguistic, reading and mathematical deficits in OM children to illustrate the existence of such deficits (Holm and Kunze, 1969; Needleman, 1977).

Exploration of the ability of OM children to devise language processing strategies could begin at the preverbal level using a longitudinal research approach. Definition of relevant variables and qualification of medical and behavioral symptoms, coupled with analysis of developing auditory skills and cognitive strategy formation would provide a multi-source baseline upon which to make judgments concerning the nature of this problem, and eventually, the efficacy of intervention techniques.

Summary

The auditory attentional abilities of a group of communicatively handicapped children with a history of recurrent otitis media (OM) were not found to be significantly different from those abilities in a group of communicatively handicapped children without an identified history of recurrent otitis media (NOM). Results of administration of four tests of auditory processing indicated that both groups had serious problems in responding to auditory attentional tasks. Discriminant analysis of test results did provide a prediction of group classification at a 75% accuracy level. Some differences in distribution of scores between stressed and facilitated attention test conditions were noted between the groups.

It was suggested that the comparison of samples of OM children to other language disordered populations provides a meaningful technique for qualifying the symptomology of this clinically prevalent population. In addition, some of the methods and procedures employed in this study were recommended in answer to many of the criticisms levied against the existing otitis media research literature. It was suggested that future research activity in this area pursue the establishment of a normative data base, refinement of methodology and longitudinal investigation of cognitive strategy development.

APPENDIX A

PARENTAL QUESTIONNAIRE



Parental Questionaire

_____(last name)

Form 2.

9 Did your child have earaches after age three years?
___a) No
___b) About one or two
___c) About one or two every year
___d) More than one or two every year

10 Did your child have nasal congestion because of colds or allergies before age three years?
___a) No
___b) About one or two times
___c) He/she was congested about half the time
___d) He/she was congested about all of the time

11 Did your child have nasal congestion because of colds or allergies after age three years?
___a) No
___b) About one or two times
___c) She/he was congested about half the time
___d) She/he was congested about all of the time

12 Did your child have his/her adenoids removed before age three years?
___a) No
___b) Yes

13 Did your child have her/his adenoids removed after age three years?
___a) No
___b) Yes

14 Did you ever take your child to the doctor because he/she had trouble hearing or trouble with ears before age three years?
___a) No
___b) One time
___c) More than one time

15 Did you ever take your child to the doctor because he/she had trouble hearing or trouble with ears after age three years?
___a) No
___b) One time
___c) More than one time

16 Did your child ever take medication for fluid in the ears before age three years?
___a) No
___b) Once for a week or so
___c) More than once

17 Did your child ever take medications for fluid in the ears after age three years?
___a) No
___b) Once for a week or so
___c) More than once

Parental Questionnaire
_____ (last name)
Page 3

18. Did your child have tubes [illegible] years?
___a) No
___b) Once
___c) More than one time

19. Did your child have tubes put in her/his ears after age three years?
___a) No
___b) Once
___c) More than one time

20. Did you ever think your child had trouble hearing or understanding speech before he/she was three years old?
___a) No
___b) Once or twice during colds
___c) For periods lasting for about a week once or twice a year
___d) More than the above

21. Did you ever think your child had trouble hearing or understanding speech after she/he was three years old?
___a) No
___b) Once or twice during colds
___c) For periods lasting for about a week once or twice a year
___d) More than the above

22. Did your child sit very close or turn up the TV too loud before age three years?
___a) No
___b) Only three or four times
___c) About half the time
___d) Almost all of the time

23. Did your child sit very close or turn up the TV too loud after age three years?
___a) No
___b) Only three or four times
___c) About half the time
___d) Almost all of the time

24. Did your child ever fail a hearing test before age three years?
___a) No
___b) Yes

25. Did your child ever fail a hearing test after age three years?
___a) No
___b) Yes

APPENDIX B
CONSENT FOR PARTICIPATION IN RESEARCH

Title: Children with Recurrent Otitis Media: Auditory Attention Under Stress
Principal Investigator. Linda M. Leeper

This study is designed to obtain information about the listening abilities of children with speech and/or language problems. Tests of your child's hearing acuity, non-verbal mental maturity level and a parental questionnaire will be administered in order to match your child to another in this study. Following this, your child will listen to another battery of tape recordings of people speaking and be asked to point to a picture or repeat what is heard. This procedure will take approximately one hour.

The principal investigator, Mrs. Leeper, will be happy to share the results of your child's testing with you. All information regarding your child's performance will be kept confidential within legal limits to be released to others, such as your child's speech clinician, only at your written request. No monetary compensation will be awarded.

I understand that I am (my child is) free to withdraw consent at any time and to discontinue participation in the study without prejudice to me or my child.

I have read and I understand the procedure described above. I agree to participate in the procedure and I have received a copy of this description.

Subject

Subject's Guardian Date Witness Date

Relationship to Subject

Principal Investigator's Name

Address

APPENDIX C
RAW DATA

CM SUBJECTS ERROR SCORES (in percentage form)

Subject Number	SSNST	SSNFC	GFNST	GFNFC	GFNSTG	GFNFCF	CSRE	CSREF	CSLE	CSLEF	ASST	ASSTG	ASFC	ASFCF
1	20	25	47	55	3	73	20	0	100	80	50	20	10	10
3	81	83	43	55	30	20	100	60	100	100	100	50	80	70
5	45	43	47	15	38	0*	80	50	50	75	70	10	90	10
7	41	65	75	1	51	0*	100	100	100	100	90	50	90	10
9	27.5	57.5	55	61	7	40	100	90	100	100	80	50	60	10
11	5	11	40	22	0	85	0	0	80	70	20	10	0	0
13	55	30	53	81	0	90	50	10	20	10	10	0	0	0
15	45	59	67	4	37	5	100	100	100	100	100	50	100	50
17	25	25	55	37	3	56	100	50	100	100	90	40	80	30
19	50	50	73	5	30	26	100	100	100	100	90	50	90	80
21	34	35	57	5	57	0*	80	50	100	100	90	50	0	0
23	37.5	66	53	57	55	42	40	50	100	100	80	40	30	10

*placed below the 1st percentile

NUM SUBJECTS ERROR SCORES (in percentage form)

Subject Number	SSWST	SSWPC	SPWST	SPWSTP	SPWPC	SPWPCP	CSRS	CSRSP	CSLC	CSLCP	ASST	ASSTP	ASPC	ASPCP
3	26	15	33	96	3	73	28	28	80	70	30	20	30	8
4	67.5	50	73	3	90	8*	200	100	90	90	90	50	70	41
6	26.5	14	30	68	3	85	80	50	40	20	90	30	30	8
8	51	70	73	1	37	2	150	200	100	100	100	100	100	90
20	27	25	47	25	3	73	40	20	90	90	50	20	30	0
13	36.5	41.5	30	54	20	18	60	50	30	30	50	20	80	20
14	25	35	33	81	10	38	200	80	100	100	70	20	60	20
28	47.5	52.5	50	20	43	8*	80	70	100	100	100	90	100	80
29	42.5	41	80	29	30	41	100	70	100	100	100	100	100	80
30	30	31	40	74	10	75	90	80	80	80	50	30	0	0
32	22.5	21	40	22	0	85	30	0	80	80	40	10	50	0
24	34	34	53	23	40	4	90	70	100	100	100	70	80	40

* placed below 1st percentile

APPENDIX D
ORAL TEST DIRECTIONS GIVEN TO SUBJECTS

Goldman-Fristoe-Woodcock Test of Auditory Discrimination

Now you will see some pictures. Listen to what (examiner) tells you, then point to the picture that shows what you hear.

(training procedure)

Now you will hear the same words through the earphones. Listen carefully to what the lady says, then point to the picture that shows what you hear. Ready?

Competing Sentences Test

You will hear a man talking to you through the earphones. Listen to him then repeat exactly what he says.

(training procedure)

Now you will hear the man say different things in each of your ears. I want you to listen only to what he says in your (target) ear. (examiner) will show you which ear. Just tell me what you hear in your (target) ear. Ready?

Rapidly Alternating Sentences Test

Now a man is going to tell you to repeat what he says. Listen and repeat exactly what he says. (training procedure)

Staggered Spondaic Word Test

Now you will repeat some words you hear. Listen carefully to what the man tells you. (training procedure)

APPENDIX E
TEST BATTERY PROTOCOLS

INFORMATION SHEET

Subject_____ Group_____
Birthdate_____ Age_____ Grade_____ Sex_____ Race_____ Therapy_____

Examiner_____ Test date_____

Hand'ers
Siblingsound_____ Clubs_____

Audiogram_____ PTA--lm_____rm_____ Tympanogram_____

Parent Questionnaire_____ Consent_____ Release_____

Test Scores

CS-RS_____ SSW-ST_____

CS-LS_____ SSW-FC_____

AS-ST_____ CPW-ST_____

AS-FC_____ CPW-FC_____

Total Error Pattern--Integration_____
Order_____
Laterality--l_____ r_____
Linguistic_____
Recall_____
Total Performance Observations--Latency_____
Confirmation_____
Negative_____

Comments:

PROTOCOL
SENSORY PATTERNS

[redacted] Date _____

Test [redacted]n	Order	Laterality lf.	rt.	Linguistic	Tonal
CS-VC					
CS-LS					
AS-P*					
AS-PS					
CSM-ST					
RS4 PS					
CPV-ST					
CPM/PS					

Total

Comments

PROTOCOL
PERIPHERAL VS CENTRAL VISION

Subject _____ Date _____

Test	Latency	Gratification	Reactive
CS-SS			
CS-LS			
AS-ST			
AS-PC			
SCV-ST			
SCV-PC			
CPM-ST			
CPM-PC			
Total			

Comments:

[illegible] LIST

[illegible] _____ In a _____ Score ____/____

[illegible] _____

[illegible] e.g. 1 The children are playing baseball.
2 Football is an exciting game.
3 Let's sit down on this bench. (T)
Let's a chair so I can rest

[illegible] (T) check on the true sentence (F) designs an [illegible]

I th[illegible] have rain [illegible]
There was [illegible] on the ground.

(T)

2 This watch keeps good time
I was late to work toda[illegible]

(T)

3 I'm expecting a phone call
Please answer the doorbell.

(T)

4 The bus leaves in five minutes
It is four blocks to the library

(T)

5 [illegible] mother is a good cook
Your brother is a tall boy.

(T)

6 Please pass the salt and pepper.
The meat loaf is very good.

(T)

[illegible]	Latency	Confirmation	Negative

[illegible]

[illegible]

1. [illegible] a car [illegible] as
[illegible] road is very slippery.

(a) _____

2. [illegible] earn the keys in the car
[illegible] the tank with gas

(b) _____

3. [illegible] We're always [illegible] on the 4th of July
The stores will be here very soon

(c) _____

4. [illegible] We had to repair the car
You should really take a taxi

(d) _____

5. [illegible] The ice cream sundae is very good
We have chocolate and strawberry today

(e) _____

12. Fasten your seatbelt
Get ready for take-off

(f) _____

3. I think you need a band-aid
You should see a doctor.

(g) _____

4. This is the latest style
That fits you perfectly

(h) _____

Cold	Latency	Description	Negative

Competing Cast - List
_____(last name)
Page 3

15 I will be back after lunch
You may take this Saturday off.

(3) _____

16 I have seen this movie before
This movie is not like the book

(3) _____

17 Air mail will get there faster
Please answer on a post card

(3) _____

18 I think we have met before;
You probably don't remember me.

(3) _____

19 This train is going West
All the cars are air conditioned

(3) _____

20 I wonder what time it is-
I think it is time to leave

(3) _____

OBSERV	Latency	Confirmation	Negative

Comments:

PROTOCOL

RAPIDLY ALTERNATING SPEECH - LIST A

Subject _____ Date _____ Score ___/___ %

Examiner _____ Alln _____ Tone ____

1 The fire engine raced down the street.

2 Do you want to go see the picnic?

3 There were many trees around the house.

4 My dog always does what I ask.

5 She is afraid to go home alone.

6 The bird flew out of its cage.

7 The puppy chased the big red ball.

8 The tree branch broke off in the storm.

9 Did you get the tickets for the game?

10 Where did you put the yellow sweater?

Latency	Observation Confirmation	Negative

Comments:

PROTOCOL
"AFRIKA ALTERNATIVE SPEECH - LIST B

Subject _____ Date _____ Score ___/___ = ___%

Examiner _____ Alta. _____ Beta _____

1 We camped in the woods last night.

2. Would you join us for coffee after school?

3 The mayor was elected yesterday

4 The secretary gave us the wrong number

5 There are many kinds of fish in the ocean

6 The children enjoyed playing at the beach.

7 The horse raced around the track.

8 Put a dozen apples in the sack.

9. There was dew on the grass this morning.

10 Plants will begin to grow in the Spring

Latency	Observations Confirmation	Negative

Comments:

T L S T EC

Se

Ide Ear R L

1 R S S W
Enter data on page 3

CONDITION	RNC	RC	LC	LNC
Total Errors				
Mul pl s	x	x	x	x
R SSW E or				
EAR	RE		LE	
R SSW E or				
TOTAL		T		
R SSW % Error				

3 A SSW
Enter response and error data from page 3

Condition	RNC	RC	LC	LNC
Errors				
Mul pl s	x	x	x	x
Item E ors				
WRS P E or	—	—	—	—
A SSW E ror				
EAR	RE		LE	
A SSW E ror				
TOTAL		T		
A SSW % E or				

PURE TONE AND SPEECH SUMMARY

	SR 1 to	SP Ave	SD SI	>3d	SDR	LDL
RE						
LE						



RESPONSE BIAS
Effects
Ear /
Order /
Pattern +
Reversals
Tone
Praise
Total

MULTIPLIERS

# Items	R SSW	A SSW
20	5	10
25	4	8
30	3.3	6.6
40	2.5	5
If other		
( )		

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2 C S S W
Enter R SSW % error

CONDITION	RNC	RC	LC	LNC
R SSW % E or				
WRS % E or	—	—	—	—
C SSW % Error				
EAR	RE		LE	
C SSW % Error				
TOTAL		T		
C SSW % Error				

COMMENTS Circumstances
Interpretive —
Treatment —
Signature —

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c.	north	west	stu	way

Left Ear / Right Ear	L.NC (A) R.NC	L.C (B) R.C	R.C (C) L.C	R.NC (D) L.NC	Raw	WRENG
1	up	under	down	own	T P	
3.	day	light	sunk	sun	T P	
5.	room	hand	sat	meal	T P	
7	flour	gate	flash	light	T P	
9	rest	cream	bag	ball	T P	
11	house	fly	wood	work	T P	
13	sun	day	than	about	T P	
15.	book	door	pay	y ound	T P	
17	snow	white	fall	hill	T P	
19	blue	top	black	bird	T P	
SUM						

	R.NC E L.NC	R.C F L.C	L.C (G) R.C	L.NC (H) R.NC	Raw	WRENG
2	no	note	a	new	T P	
4	wash	tub	black	board	T P	
6	hot	spoon	mouth	room	T P	
8.	see	shoe	eat	rode	T P	
10	black	board	air	sof t	T P	
12	green	home	house	loud	T P	
14.	white	milk	dog	house	T P	
16	school	boy	church	hurt	T P	
18	hand	new	rain	mid	T P	
20.	no	red	sweet	moon	T P	
SUM						

COMMENTS: _____

PAGE 1

	A	B	C	D	Row Tot	WRONG
21	[illegible]	eye	moth	brush	Tot	
23	mik	rag	[illegible]	oon	Tot	
2	bag	sku n	wi	cuse	Tot	
[illegible]	sun	[illegible]	sony	flukun	Tot	
[illegible]	ner	[illegible]	lump	light	Tot	
[illegible]	[illegible]	sugs	crow [illegible]	nou	Tot	
2	[illegible]	[illegible]	brag	khure	Tot	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tot	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tot	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tot	
[illegible]	[illegible]	horse	river	cas	Tot	
[illegible] Page 2						
[illegible] Page 2						
TOTAL						
[illegible]	L.NC	L.C	R.C	R.NC		

	E	F	G	H	Row Tot	WRONG
22	[illegible]	[illegible]	cup	cake	Tot	
24	[illegible]	light	yard	st ek	Tot	
26	play	ground	bat	boy	Tot	
28	[illegible]	day	flat	place	Tot	
30	flour	hook	now	ball	Tot	
32	wee	end	work	day	Tot	
34	wood	work	brush	cold	Tot	
36	Irish	net	sky	we	Tot	
38	sheep	sk n	hill	dog	Tot	
40	grass	house	string	hom	Tot	
[illegible] Page 2						
[illegible] Page 2						
TOTAL						
[illegible]	R.NC	R.C	L.C	L.NC		

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

PAR EFFECT

Tot R n	NC	C	NC

☐ Sig
☐ N Sig

REVERSALS

Tot	Page 1	Page 2

OPEN EFFECT

1	2	3	4

1 FIRST SYMBOLS R | SI CORD SI SYM I C

☐ Sig ☐ N Sig

COMBINED TOTALS

	R.NC	R.C	L.C	L.NC
[illegible]				
[illegible]				
[illegible]				
[illegible]				

Enter the A figures on Page

GOLDMAN-FRISTOE-WOODCOCK

TEST OF AUDITORY DISCRIMINATION

AGS

By Ronald Goldman, Ph.D., Macalyne Fristoe, M.S., and Richard W. Woodcock, Ed.D.

TRAINING PROCEDURE
Words Paired to Train
TOTAL WORDS ____
TEST WORDS ____

QUIET SUBTEST
TOTAL ITEMS ____
INCORRECT ____
RAW ____

NOISE SUBTEST
TOTAL ITEMS ____
INCORRECT ____
RAW ____

NAME _____ AGE _____ GRADE _____ SCHOOL _____

EXAMINER _____ DATE _____

Tape Player: Make _____ Model _____ Earphones Used: ☐ Yes ☐ No Possessing with Large Training Plugs: ☐ Yes ☐ No

TRAINING PROCEDURE

Stimulus stimuli responses by 1 2 3, incorrect responses by 1 zone etc. Blank spaces indicate that not administered.

Items	Stimulus Word	1st Try	2nd Try	3rd Try
1.	chair	____	____	____
	bear	____	____	____
2.	light	____	____	____
	bright	____	____	____
3.	pay	____	____	____
	play	____	____	____
4.	cast	____	____	____
	sports	____	____	____
5.	blend	____	____	____
	bend	____	____	____
6.	shade	____	____	____
	rain	____	____	____
7.	porch	____	____	____
	fellow	____	____	____
8.	store	____	____	____
	tailor	____	____	____
9.	four	____	____	____
	seven	____	____	____
10.	below	____	____	____
	above	____	____	____
11.	place	____	____	____
	space	____	____	____
12.	poop	____	____	____
	night	____	____	____
13.	shirt	____	____	____
	dress	____	____	____
14.	cross	____	____	____
	bag	____	____	____
15.	cats	____	____	____
	hats	____	____	____
16.	chime	____	____	____
	sand	____	____	____

Return to those items and repeat the stimulus pair a different way.

If zone 4 and 5 are cats before it means experience exercises Means to give Words

Give the next item, being sure that the child understands the "S-M."

QUIET SUBTEST

Record the number of the subject responses for each item. It necessary to show the the procedure due to time subject Personal phone a person 1 2 number Points

Items	Word	Items	Word
17.	monk	38.	cone
18.	eight	39.	beer
19.	dig	40.	bike
20.	wig	41.	cap
21.	hot	42.	cop
22.	bell	43.	shop
23.	hook	44.	shoe
24.	look	45.	chop
25.	knife	46.	shoe
26.	nose	47.	the
27.	rope	48.	thin
28.	rowing	49.	make
29.	pool	50.	back

To score every subject through the subtest proceed to the "Correct Responses" column.

Items	Word	Items	Word
30.	cone	51.	fan
31.	bike	52.	fin
32.	cap	53.	sun
33.	cop	54.	sung
34.	shoe	55.	tub
35.	chop	56.	tuck
36.	shoe	57.	bug
37.	the	58.	rug

To score every subject through the subtest proceed to the "Correct Responses" column.

ERROR ANALYSIS

	Sound	Total Errors
Initial		
Medial		
Final		

ERROR ANALYSIS

	Sound	Total Errors
Initial		
Medial		
Final		

NOISE SUBTEST

Record the number of the subject's responses for each item. If necessary to show the the procedure due to time subject responses, use a number 1 2 number Points

Items	Word	Items	Word
59.	bear	80.	bee
60.	bike	81.	cap
61.	cop	82.	cop
62.	dig	83.	dig
63.	dock	84.	dock
64.	eight	85.	fan
65.	fin	86.	fin
66.	hook	87.	hook
67.	knife	88.	knife
68.	look	89.	look
69.	monk	90.	monk
70.	nose	91.	nose
71.	rope	92.	rope
72.	rowing	93.	rowing
73.	sung	94.	sung
74.	the	95.	the
75.	thin	96.	thin
76.	tub	97.	tub
77.	tuck	98.	tuck
78.	bug	99.	bug
79.	rug	100.	rug

To score every subject through the subtest proceed to the "Correct Responses" column.

ERROR ANALYSIS

	Sound	Total Errors
Initial		
Medial		
Final		

ERROR ANALYSIS

	Sound	Total Errors
Initial		
Medial		
Final		

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APPENDIX F
RESEARCH TAPE RECORDINGS
SUBTEST PRESENTATION ORDER

I.	CS-RE,LE	III.	SSW-FC,ST
	AS-ST,FC		GFW-ST,FC
	SSW-FC,ST		CS-RE,LE
	GFW-ST,FC		AS-ST,FC
II.	AS-FC,ST	IV.	GFW-FC,ST
	SSW-ST,FC		CS-LE,RE
	GFW-FC,ST		AS-FC,ST
	CS-LE,RE		SSW-ST,FC

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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